Power to the People:
A Framework for Enhancing Environmental Stewardship through Community Design

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**ABSTRACT**

The actions and activities of average Americans contribute greatly to global warming, fossil fuel consumption, natural resource depletion, and other environmentally-related threats to humankind. Currently, the negative impacts of these actions are most commonly addressed through "green" design strategies that utilize largely technological solutions to increase the resource efficiency of the built environment. However, "green" design as currently comprised is insufficient; while it effectively reduces the amount of resources consumed in households, it fails to address the wasteful and inefficient actions of the building occupants themselves.

A number of deeply ingrained psychological and behavioral qualities contribute to the general failure of individuals to change their behaviors and become more effective environmental stewards. Such human qualities are reinforced by residential design and development patterns that disconnect people from natural systems and resources, mask the consequences of environmental neglect, and perpetuate cycles of environmental disinvestment.

This thesis explores the potential of using residential design as a medium for confronting these human qualities to instill a desire and provide the ability to protect and conserve natural resources, and address other emerging environmental threats. After a brief introduction to the core problem at hand, the thesis explores existing approaches for mitigating the negative environmental impacts of the residential sector. The shortcomings revealed in this discussion suggest a need for an alternative approach, called "pedagogical design". It then builds the foundations for a pedagogical design framework by both examining the human qualities which underlie the failure of individuals to act as environmental stewards, and studying strategies used in academic contexts to promote environmental stewardship. Finally, it synthesizes these findings and translates them into a set of design guidelines for approaching, prioritizing, and designing residential communities through the pedagogical design lens. These guidelines form a platform on which to base further research, and comprise a design approach for enhancing people's ability and sense of duty to protect and conserve natural resources.

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# TABLE OF CONTENTS

## *Introduction*

"This is a design challenge like no other. It is not about making greener widgets…the issue is whether the emerging field of ecological design will evolve as a set of design skills applied as patchwork solutions on a larger pattern of disorder or whether design will eventually help to transform the larger culture that is badly in need of a reformation…The problem is not how to produce ecologically benign products for the consumer economy, but how to make decent communities in which people grow to be responsible citizens and whole people."

*--David Orr (Orr 2002)*

The beginning of the 21st century has been marked by threats of global warming, sicknesses associated with soil, air, and water pollution, and global instability triggered by dwindling natural resources. Responsibility for solving these problems primarily rests in the hands of scientists, engineers, and policy-makers, who through new technologies and sweeping top-down regulations, are shaping a society in which the average American's daily life is insulated from the burden of addressing these environmental threats. Yet as new "green" technologies such as coal-gasification plants and energy-efficient light bulbs are designed to squeeze every last energy molecule from our existing fossil resources, and as hotly contested regulations are negotiated to cap industrial pollution, many American households unknowingly waste precious resources and demand goods that further exacerbate ecological problems. Therefore, to complement these changes from above, Americans must also address environmental threats at the source by tapping into the country's largest and most available renewable resource: the collective power of 300 million people whose daily habits and behaviors fuel, rather than reverse, the environmental crisis.

Although people are quick to blame China, other developing countries, and the industrial sector of the domestic economy, American households contribute greatly to global warming, pollution, and resource shortages. The United States consumes 26% of the earth's energy and is responsible for 23% of global carbon emissions—making it the top emitter of greenhouse gases in the world (SEI 2007). 21% of the fossil fuels burned in the United States stem directly from the residential sector (SEI 2007). In addition, households dispose enough waste every year to match the equivalent weight of roughly 800,000 average size cars, a staggering figure contributing to overflowing landfills, polluted soils, and the depletion of those resources used to replace whatever is thrown away (USEPA 2006). Americans also display an insatiable demand for potable water. Rapid residential development drains rivers, lowers water tables, and sparks costly political battles for water rights—a problem further exacerbated by the increasingly polluted water supply (Frederick 1995).

The homebuilding industry is beginning to take steps to address the environmental impacts of the residential sector through a blossoming "green building" movement and the adoption of new green building standards. Green design and construction holds a great deal of promise for increasing the energy, material, and resource efficiency of the built residential environment. However, it often fails to directly address the original source of resource demand: the wasteful and inefficient actions of building occupants who remain largely indifferent to environmental issues and resistant to altering their own behavioral patterns.

Timothy Beatley, Professor of Sustainable Communities at the University of Virginia, argues that individual apathy toward addressing environmental issues may be linked to the design of the built environment. "The modern home, whether a single-family suburban residence or a multistory urban apartment building, has been fundamentally de-physicalized, or disconnected from the landscapes and eco-systems that support it," Beatley says. "The average homeowner couldn't accurately tell you the name…of the watershed in which their house is located, where water and energy comes from, where wastes are treated and disposed of, and so on. Food comes from the grocery store and energy from the power grid (or even more basically, from the light switch)" (Beatley 2004). The disconnection that modern "de-physicalized" developments perpetuate inhibits people from understanding personal relationships to natural systems and perceiving the consequences of environmental neglect and mismanagement. As a result, residential developments largely reinforce a cycle of environmental disinvestment and prevent individuals from altering their behaviors to be better environmental stewards.

If designers could understand how to design homes and communities that remove this barrier, they could create living environments that reinforce people's connection to their world, and instill an emotional desire and ability to protect and conserve natural resources, eco-systems, and the natural environment. This approach could catalyze the development of a population in which individuals 1) have a greater understanding and appreciation of the natural environment, systems, and processes, and 2) behave in ways that reduce greenhouse gas emissions, conserve energy, decrease household waste, and curb excessive water consumption, and 3) become engaged in addressing newly emerging environmental threats.

This thesis explores the question of how designers can conceptualize a new design framework for residential development that achieves these goals. Unraveling this question will take place over the course of four chapters. Chapter I examines the shortcomings of the current paradigms which underlie 1) technological, 2) economic, and 3) educational approaches for mitigating negative individual impacts on the environment in the residential sector. This analysis will reveal the need for a relatively unexplored and complimentary fourth approach, which I call "pedagogical design," that utilizes the products of planning and design to encourage more effective personal environmental stewardship.

Chapter II lays the foundations for this alternative approach by exploring some of the factors that behavioral psychologists say underlie people's failure to individually address environmental problems in the first place. It discusses several key factors that designers must understand before attempting to shape communities that engender new attitudes and behaviors.

Chapter III searches for strategies capable of addressing these behavioral limitations in residential contexts by exploring place-based environmental education, an existing teaching method that aims to develop individual responsibility for environmental stewardship in academic contexts. Examining the underlying theory and key tenets of this pedagogy reveals several important strategies that can be applied to residential developments.

Chapter IV synthesizes the insights from behavioral psychology and place-based education into a set of guidelines that provide an operational framework for approaching, prioritizing, and designing residential development through the pedagogical design lens. An illustrative scenario demonstrates how these guidelines might manifest themselves in a completed housing community. The proposed guidelines offer a platform for further innovation and elaboration from within the design community, and represent steps toward solidifying a design approach that envisions residential development as a medium for unlocking the American population's collective ability to carry its weight in addressing global environmental threats.

# *Chapter I:*

## *Addressing Environmental Impacts*

"People are more than a source of heat gain, they do not act on economic criteria alone, they have models about how their world works and base actions on those models…they operate within a social framework and at the same time they consume energy."

*--Bell et al (Bell 1996a)*

As the residential sector's collective negative impact on natural systems, resources, and eco-systems has increased, numerous approaches have been developed and implemented to ameliorate these pressures. The majority of these methods are encompassed by three dominant paradigms based on 1) technological, 2) economic, and 3) educational frameworks that inform and define how specific environmental problems are conceptualized and addressed. This chapter examines the strengths, shortcomings, and implications of each paradigm's application in the residential sector in order to demonstrate the need for a complementary fourth paradigm based on a "pedagogical design" framework.

Each existing paradigm is an outgrowth of a particular professional specialization that utilizes its core competencies to frame and address issues. As a result, with the exception of education, these paradigms tend to result in "top-down" strategies for mitigating human environmental impacts. Alternatively, pedagogical design aims to stimulate "bottom-up" change by unlocking people's individual potential to serve as more effective environmental stewards and demand fewer resources.

No single mode of thinking can produce solutions capable of entirely ending ecological neglect and mismanagement. However, viewing each paradigm as part of a larger, integrated approach reveals opportunities and gaps that pedagogical design can fill in order to advance the development of a more sustainable society.

### *Paradigms*

This chapter examines three major paradigms that underlie and encompass the dominant approaches to reducing people's environmental impacts in the American residential sector:

1) *The Technological Paradigm*: Ecological impacts of the built environment can be reduced through technological and design innovation.

2) *The Economic Paradigm*: People can be motivated to reduce their environmental impacts through the use of extrinsic economic incentives.

3) *The Educational Paradigm:* People can be motivated to reduce their environmental impacts through the dissemination of information that teaches new attitudes and behaviors.

### *Technology*

New "green" building practices hold considerable promise for improving the resource efficiency of the built environment and reducing the overall ecological impacts of human development. Thanks in large part to technological, engineering, and design innovation, homes now achieve greater energy efficiency, produce less pollution and fewer greenhouse gas emissions, and demand fewer natural resources in both their construction and operation.

The predominance of this focus on increasing the resource efficiency of the built environment is evident in the language of today's most prominent green building literature. "Buildings in the United States consume more than 30% of our total energy and 60% of our electricity annually," says the introduction of the United States Green Building Council's LEED 2.1 Green Building Reference Guide. "...buildings account for 49% of sulfur dioxide emissions, 25% of nitrous oxide emissions, and 10% of particulate emissions – all of which damage urban air quality. Buildings produce 35% of the country's carbon dioxide emissions" (USGBC 2003). While these figures are undoubtedly true, such statements would be more accurate if they stated that the *people* inhabiting these buildings consume more than 30% of our total energy and 60% of our electricity. The same concept may be transferred to other actions which tax natural resources. Buildings do not demand land, people demand land. Cars do not demand roads, people demand roads. Houses do not produce waste, people produce waste.

The emphasis on addressing the resource demands of physical structures and systems, rather than the human source of the demand, can be partly attributed to the building industry's heavy reliance on technology and engineering to address environmental concerns. Environmentally sensitive and sustainable housing developments in the United States are generally characterized primarily by technology-driven efficiency measures such as low-energy appliances, energy efficient building systems, low-flow sinks and toilets, and thicker insulation. Such features enable residents to continue living as usual while technology takes care of the resource conservation. For example, compact fluorescent light fixtures can reduce lighting energy consumption by 66% over a normal light fixture (Energy Star Accessed 2007) and low flow shower heads can reduce shower water consumption by 44% (www.fypower.com 2007) without residents giving a thought to resource conservation. These resource saving solutions are considered during the design and construction process, modeled in simulation programs, and then disappear into the background during occupancy. A family living in a home shaped by this process could conceivably have no idea that their home was any different from a standard home. As a result, their daily lives remain untouched by the larger issues which necessitate the need for resource conserving technologies in the first place, and they could remain unengaged in the problems triggered by wastefully leaving on the lights or running excessive hot water in the first place.

This disengagement would not matter if technological innovation could free us entirely from the consequences and limits of natural resource exploitation. Unfortunately it cannot. For example, while the last 25 years have brought great improvements in energy-efficiency technology, many buildings including those designed to meet net-zero energy standards (the building produces as much energy as it consumes), still fail to achieve projected energy savings despite the inclusion of advanced technological solutions (Malin 2005). Why do buildings so often fall short of stated energy goals? Many factors, such as unreliable technology, poor design, and inaccurate energy modeling software are partially to blame (Malin 2005). However, an often overlooked factor that can lower a building's estimated performance has less to do with the success or failure of technology, and more to do with the attitudes and behaviors of building occupants (Malin 2005).

Buildings can be engineered to alter the resource demand of appliances, lights, and heating and cooling systems, but only people can reduce their own demand for resources. A wide range of energy outputs can come from efficiently designed buildings with identical designs, systems, and locations—variances that can only be explained by occupant factors (Williams 1985, Bell 1996a). Regardless of a home's engineered resource efficiency, resident commitment and interest in conservation drive energy reduction and are critical to realizing the full savings potential of residential buildings (Bell 1996a, Rosenbaum 2007). For example, someone might live in an apartment supplied with compact fluorescent lights, but leave every light in the apartment turned on all day long. This will erode the overall savings potential of the compact fluorescent fixtures. "The technology part is fairly straightforward," says Ron Perkins, an engineer and principal of Supersymmetry USA, "but the people part is challenging" (Malin 2005).

Despite evidence of the behavioral influence on resource consumption, those operating within the technological paradigm rarely seek to understand human actions and motivations. For example, engineers commonly view people simply as physical bodies that impact heat gain, rather than considering them as individuals who consume resources in accordance with particular motivations and urges (Lutzenhiser 1992). People are also commonly viewed as obstacles to achieving "perfect" system optimization, rather than as assets and potential allies in achieving greater conservation goals (Parnell 2005). This perspective leads engineers and architects to minimize human control by limiting people's ability to influence and manipulate their surroundings (Bell 1996a). Eliminating the potential for behavioral adaptations to contribute to solutions raises the concern that "if only engineering solutions are sought, there is a danger of setting up a viscous circle in which more engineering simply leads to more engineering" (Bell 1996a). In those instances where users are given control, system design can prove overly confusing and difficult to understand, read, and manipulate (Bell 1996a).

The way that the technological paradigm deals with the relationship between people and their surrounding environments is a key issue that demands greater examination. A common characteristic of 19$^{th}$ and 20$^{th}$ architecture involved the engineering of environmental systems so that those deemed undesirable, such as sewers, plumbing, and electrical systems, were hidden from view so to remove any sensory clues to their existence. "Nature" was often paved over and replaced with ecologically sterile materials such as asphalt and lawn turf. The home, in essence, became a machine – a mechanical fortress that protected people *from* nature, rather than a place for people to experience living *with* nature. The majority of today's homes follow in this tradition: energy magically appears at the flick of a light, drinking water flows from hidden pipes and unknown sources, polluted rainwater is carried away by seemingly bottomless sewer drains, and household waste disappears from dumpsters into far-off unknown "voids". Turf and asphalt dominate landscapes, and native eco-systems and habitats in residential areas are largely missing. As a result, residents receive little opportunity to understand the role and function of natural systems, and the economic, social, and environmental consequences of irresponsible natural resource use. Without this knowledge, they fail to establish a personal relationship with the resources which support them – a fact that perpetuates the "de-physicalization" and disconnection discussed previously by Tim Beatley.

Technology's ability to mask people's dependence on natural resources and systems perpetuates a myth that humans are not subject to limitations imposed by nature (Orr 2002). If people believe that technology alone can overcome any limitation, such as water or energy availability, there will be no motivation to alter personal behaviors. It becomes easier to believe that resource supplies are endless, that the land, water, and air can be continually abused, and that individual actions have no environmental consequences. "Nothing seems less likely than the idea that people, having perceived themselves to be beyond the limits of nature, would voluntarily limit their appetites for ostensibly spiritual or moral reasons," says David Orr, Professor of Environmental Studies at Oberlin College. "Having dismissed the concept of limits we will simply not see them when they present themselves to us, especially if they are the small things in nature or if they involve the slow loss of natural services. We will have lost the ability and patience to pay attention" (Orr 2002).

Technological approaches also tend to reinforce a dependence on solutions with short-term quantifiable and measurable outcomes, rather than immeasurable qualitative elements that might deeply impact a resident's resource consumption. For example, engineers reduce the amount of water expelled from a showerhead so they can state that their design saves X number of gallons per year. However, they are not trained to create designs that teach residents about where their water comes from, how it is polluted and cleaned, and how they personally fit within the larger contexts of the hydrological cycle – knowledge that might not yield easily quantifiable results, but could potentially cause people to be more careful and aware of their water consumption. Other consultants, such as hydrologists and ecologists would most likely have to be included on a project to effectively achieve this goal. Unfortunately, over-reliance on technological solutions results in their exclusion.

The criticisms above are not intended to dismiss the value of technology in creating a more sustainable built environment. Engineering and technology are both critical for achieving significant gains in resource conservation and developing new "green" products, energy efficient systems, and low-impact materials. However, addressing environmental threats involves more than simply increasing the efficiency of the built environment. "If climatologists are right that we need to bring the world's carbon dioxide emissions to at least 80 percent below 1990 levels by 2050 to stabilize the climate, we're unlikely to succeed with new equipment alone," says environmentalist and writer Bill McKibben. "We need new attitudes and behaviors, not new light bulbs and reactors" (McKibbon 2007).

Therefore, perhaps the greatest untapped potential of technological paradigm rests in its application to develop and utilize new approaches that heighten people's personal relationship to the natural world, resources, and processes on which everyone depends – not to enable them to be shut out. "While we need to learn more about physical problems and their solutions as well," states architect and planner Peter Seidel, "it is essential that we recognize that the major obstacles to real progress lie deep within each one of us…" (Seidel 1998).

### *Economics*

The economic paradigm conceptualizes the source and solution to environmental problems as rooted in economics – if it is economically advantageous for people to address environmental threats, they will do so. Therefore, economic incentives are used to influence human behavior by creating fiscal conditions that motivate individuals to perform certain actions. While the economic paradigm does recognize that the collective behavioral shifts of a population can ameliorate environmental pressures, "top-down" economic incentives are not a wholly effective final solution for motivating environmental stewardship.

Economic incentives assume that a person will always utilize a "rational" decision-making process to choose behaviors that maximize his or her individual economic benefit. For example, if a woman knows that tax credits attached to the purchase of a hybrid vehicle will save her $3000 over the purchase of a standard all-gasoline model, rational economic models say that she will purchase the hybrid model. However, people do not always act in predictable, objectively rational ways that economic incentives depend on. Rational decisions are the result of a highly subjective multiple variable decision-making processes that might result in outcomes that appear irrational in a purely economic sense (Lutzenhiser 1992). In fact, studies show that individuals are more likely to undertake behaviors that minimize disruption, uncertainty, and risk, rather than those that provide the most economic payback (Bell 1996a).

Since no universal meaning of "rational decision-making" exists, what might appear rational to one person could seem entirely irrational to someone else. This subjectivity creates difficulty for accurately predicting behavioral reactions to particular incentives. "The goal of dispassionate, cold, calculating rationality is unattainable for humans, and is to be written off," says conservationist and ecologist E.N. Anderson. "Real world cognition and decision making rest on a number of cognitive processes…many of these run counter to rational decision making to optimize utility" (Anderson 1996).

Applying this human reality to the hybrid car example, it seems entirely possible that despite the availability of a tax credit to reduce her costs, the prospective car buyer will purchase the all-gasoline vehicle due to its reputation for dependability and safety, her familiarity with the traditional gasoline technology, or the car's availability in her favorite shade of purple. In addition, if she does not care about reducing her fuel consumption or negative environmental impacts, she might not even look closely enough at purchasing a hybrid vehicle to know about the tax credit's availability in the first place (Bell, 2007c). Real people are far more complex than the rational behavior models economic incentives rely upon. As a result, dependence on economic incentives leaves gaps that fail to recognize people's underlying motivations; a fact which can result in strategies that are not wholly effective (Stern 1986).

Another problem with economic incentives is their concentration on targeting behaviors through purely extrinsic motivational measures. As a result, if an external economic incentive disappears, it could easily spell the end of a desirable action. This can be illustrated again with the hybrid vehicle example. Hybrid sales in the US have been tightly linked to rising and falling gas prices. Rising fuel prices drove a 139% increase in hybrid sales between 2004 and 2005 (Associated Press 2006). However, as gas prices steadily dropped, so did hybrid vehicle sales. Between August of 2006 and January of 2007, fuel prices dropped 24%. Hybrid sales decreased a corresponding 31% (Benton 2007). These facts suggest that without the incentive, people were less motivated to purchase an environmentally friendly car model. This experience tells us that to achieve more sustainable behavior change, people must also be driven by an internal motivating force that remains constant, not by a purely external force that comes and goes.

Incentives can act as a catalyst for engaging residents in forming new internal motivations for their actions (Parnell 2005). Some incentives provide an avenue for people to learn why that particular incentive is necessary in the first place. For example, analysts have noted that despite its high correlation to fuel prices, purchasing a hybrid vehicle has never made economic sense; gasoline prices have never reached a price point that owners would be able to "payback" the premium paid for their purchase through the money saved from decreased gasoline use (Isidore 2007). However, the increased visibility of the Prius and other hybrid vehicles on American roads, thanks in part to the perceived purchasing incentive brought by high fuel prices, has helped generate publicity about how hybrid vehicles can reduce greenhouse gas emissions. As a result, some analysts believe that the hybrid vehicle market might now be driven by people who possess an internal motivation to reduce their environmental impacts and be perceived as environmentally friendly, rather than by those who believe they are making a smart economic choice (Isidore 2007).

The economic paradigm has an important role to play as a part of a larger comprehensive solution for addressing environmental concerns in the residential sector.

It may be used to formulate approaches for altering behavioral characteristics concerning personal transportation habits, home energy use, water consumption, waste disposal, and other sources of environmental threats. However, economic incentives are not always effective at reaching an individual's core motivations and may fail to initiate sustainable results. These inherent weaknesses point to a need for more sustainable and intrinsically motivated behaviors driven by something other than an external economic force alone.

### *Education*

The primary goal of the educational paradigm is to disseminate information that drives internally motivated behaviors of environmental stewardship. This paradigm holds that environmental problems primarily stem from individuals' lack of information. Therefore, providing new information about the importance of caring for natural resources and systems, and arming people with the knowledge to modify their behaviors to do so, is seen as the key to spurring collective "bottom-up" change through individual action.

A primary problem with education, as it currently relates to residential contexts, is the lack of unimpeded information channels that connect people to the existing range of educational programs and materials focused on environmental responsibility and stewardship. Formal educational programs are typically aimed at children, but typically only reach the small number of kids enrolled in the schools or programs that focus on environmental issues. Many schools are simply too preoccupied with meeting state standards and prescribed curricula that environmental education is not prioritized or explored as a curricular theme. In addition, adults are often too busy with the stresses of work, family, and everyday life to read or take part in available energy conservation or low-impact lifestyle seminars. As a result, such educational opportunities are peripheral and low priority commitments.

People's motivation to learn is another problem associated with education. For example, the internet is filled with web sites, such as the Energy Star web site (energystar.gov), which provides important information regarding why and how an individual can modify behaviors to reduce energy consumption. However, unless a person is interested in energy conservation in the first place, or has some reason or context to consciously seek out information, it is unlikely they will ever access it. In addition, even if people are provided with information, the chance remains high that they will not absorb or act on it (Geller 1981), a fact that will be explored in more detail in Chapter II.

One approach used to overcome these barriers is to open educational and informational channels directly into housing communities. Property managers, homeowner's associations, and developers with access to residents each have the potential to make information streams more readily available. Unfortunately, however, these entities often do not perceive themselves as

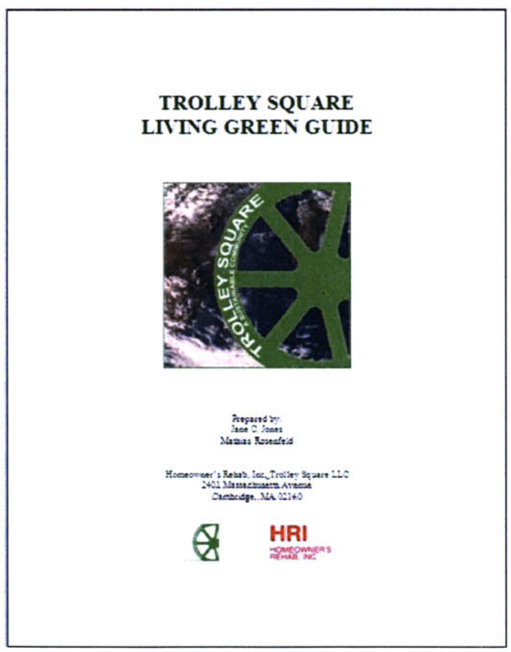


**Figure 1. The Trolley Square Living Green Guide.**

educators, lack the resources or knowledge to devise or provide environmental information, or simply do not see education as an important priority.

Homeowners Rehab Inc. (HRI), a non-profit affordable housing developer located in Cambridge, MA, has accepted the challenge of providing resident education in an attempt to lower the development's utility bills and expand the environmental knowledge-base of their residents. As part of Trolley Square, a new 40-unit rental and condominium development which opened its doors in late 2006, HRI wrote and distributed a "Trolley Square Living Green Guide" designed to provide residents with specific advice for living a healthy, low-impact, and resource efficient lifestyle. The Living Green guide offers tips for reducing energy bills, limiting water consumption, cleaning with non-toxic materials, purchasing organic produce from local farm stands, and recycling household waste. It also gives resources for tapping into other forms of environmental education within the community (Jones 2006).

While HRI has not yet measured the impacts of this educational effort, their initial instinct regarding its effectiveness hints at this method's shortcomings. "My sense is that people are so involved in moving in that some people use it, but other people didn't read it or they just got too busy," says Jane Jones, the Senior Project Manager of Trolley Square (Jones 2007). This statement reinforces the idea that people might remain generally disinterested in learning such information because of the guide's passive nature. If people are not concerned with environmental issues in the first place, there is little motivation for them to expend the time or effort to bother reading. Even if they do read it, they might not possess the contexts to absorb the new information. To combat this problem, Jones plans to hold events that will more directly capture residents' attention.

"We plan to have workshops with families about environmental issues, invite guest speakers, hold potluck dinners, hold environmental related contests for the kids, have earth day celebrations, and plan other fun events...to help engage residents with these issues," Jones says (Jones 2007). Unfortunately, time and resources from both the resident and the developer remain key barriers which prevent turning these plans into reality.

Education holds a great deal of promise for addressing environmental issues in residential contexts. However, information is often provided without effectively engaging people or giving them a real reason to care. As a result, new knowledge might not translate into new behaviors. These problems will be explored in greater detail in the remaining chapters.

### *Conclusion*

Forty years after the advent of the modern environmental movement, Americans still struggle to keep their actions from negatively impacting natural resources and systems. The three major paradigms discussed in this chapter reveal the promise and shortcomings of the strategies currently being utilized. Technological innovation addresses the efficiency of the built environment, but often fails to impact human attitudes and behaviors. Economics can help motivate human behaviors by appealing to monetary desires, but also yield results that are unpredictable, unsustainable, and require an extrinsic "top-down" motivating force. Education depends on new information as a means to change attitudes and stimulate "bottom-up" change, but is rarely implemented in residential contexts and can fail to genuinely engage residents.

After four decades, it is time to explore other complimentary approaches. We need more than efficient technologies, effective incentive policies, or more engaging informational strategies. We need entirely different ways of conceptualizing the roots of environmental problems, and new solutions for addressing the environmental impacts of the American residential sector.

Pedagogical design offers a relatively unexplored means for both conceptualizing and addressing environmental threats. It maintains that environmental problems do not rest wholly in inefficient buildings, economics, or a lack of information, but are rooted deeply within each one of us; wrapped in the psychological, behavioral, and cognitive human qualities that explain people's inability to effectively protect and steward over natural resources and systems. We will explore these human conditions in Chapter II.

## *Chapter II:*

## *The Psychology of Stewardship*

"We can work to reduce what prevents us from clearly seeing and changing our situation. And we can nurture human qualities that will guide us to act more wisely and responsibly…We must act consciously, not just as individuals, but as a species. We have been pushed into the present with its problems by our instincts and urges. We must now end this passive drifting and take control of our own destiny. To successfully do so, we need to have a better understanding of ourselves..."

*-- Peter Seidel (Seidel 1998)*

Designing homes and communities which inspire environmental stewardship first requires a basic understanding of human behavior. This chapter explores the internal psychological, cognitive, and behavioral processes that have resulted in the environmental apathy and neglect demonstrated by many Americans today. What prevents people from acting with an individual sense of responsibility for protecting the environment? Why do individuals waste precious resources, pollute and destroy sources of nourishment, and enable policies and patterns of land use that perpetuate cycles of further environmental disinvestment? The following discussion explores several possible interrelated explanations that must be understood before attempting to devise strategies for overcoming them.

***Disconnection.*** Individuals' perceptions of the world are shaped through the events and interactions of daily life. Every experience shapes a person in some small way, and contributes to building a larger psychological model of how they understand and relate to others and their surroundings. Unfortunately, these experiences are generally processed, internalized, and synthesized by the brain as discrete bits of information (Seidel 1998). As a result, highly connected concepts and events often remain internally un-synthesized and treated as independent and disconnected ideas. This disconnection leads to the formation of attitudes based on limited perspectives and incomplete mental models of how the world functions.

In environmental contexts, this cognitive limitation seems to manifest itself in 1) difficulty perceiving the connection between daily life and the vast network of both natural and engineered systems and resources which provide people with sustenance, health, comfort, and nourishment (Beatley 2004), and 2) a general failure to connect individual actions with environmental consequences (McClelland 1981). Unfortunately, homes and communities often foster these disconnections rather than assist in assembling more connected psychological models. People rarely experience any kind of direct environmental consequences from an everyday action, nor do they always possess the contexts to understand what those consequences might be (McClelland 1981). For example, the ecologically destructive processes in which fossil fuels, lawn fertilizers, and waste products are created and transported, occur far from the average American's sight. Many resources are culled from seemingly endless and "invisible" sources; energy and water, for example, are acquired by consumers with almost no effort and hardly any negative consequences other than a monthly bill (McClelland 1981). In addition, human senses are incapable of directly perceiving the minutia of the pollutants breathed in the air, drank in the water, handled in the soil, and consumed in food (Seidel 1998). These realities make it easy to believe that resources are endless and that their use has no negative repercussions. One might pass a power plant everyday on their drive to work and lament the plumes of smoke being released into the sky, but fail to link the air conditioner blasting in their empty apartment as a source of that pollution.

People also have difficulty making connections across time. Temporally distant events are generally perceived as less important than those with immediate impacts (Seidel 1998). "Much of the problem lies in the human tendency to set unrealistic discount rates," argues ecologist E.N. Anderson. "Humans seem to value even a very small present good over a very large future good" (Anderson 1996). For example, people have been extremely slow to respond to warnings about large-scale environmental threats, such as global warming, because tangible consequences are not expected to have an impact for many years beyond the scope of this generation's lifetime.

The difficulty making connections has enabled people to ignore many looming environmental threats, and absolve themselves of personal responsibility for environmental stewardship. Up until this point in time, humans have had no evolutionary need to be concerned with controlling their resource use or impacts on the environment. Survival was based purely on our ability to exploit the resources the earth afforded us. As a result, human senses have not evolved to enable an instinctive sensitivity to these connections. However, human survival now does depend on a greater awareness. Therefore, in planning new residential developments, these connections must be made more explicit to help spur more connected psychological models on which attitudes and behaviors are based.

***Distraction and Low-Mental Prioritization.*** People's brains are continually bombarded with a seemingly infinite range of stimuli that constantly compete for directed attention. Fortunately, the brain's filtering mechanism prioritizes this information to help individuals process and absorb what is critical for personal survival. Issues that hold the most day to day personal relevance, such as jobs, families, and sustenance, therefore tend to get a higher mental priority for directed attention than information which might appear irrelevant to daily life; information of no immediate personal concern rarely gets fully processed (Seidel 1998). The psychological, temporal, and sensory disconnections discussed previously result in environmental issues often appearing irrelevant to daily life. As a result, people's brains devote less directed attention and assign a very low mental priority to engaging with these issues. People are often too distracted with the endless number of other issues in everyday life to direct thoughts toward stewardship. Therefore, it is essential to find ways to increase the relevance of specific environmental issues in daily life, and provide constant reinforcing reminders to direct attention towards dealing with these issues through everyday actions.

***Difficulty Unraveling, Processing, and Retaining Information.*** New attitudes are generally slow to form because the brain takes time to internalize new ideas and concepts. "The rate at which we collectively learn and assimilate new ideas has little to do with the speed of our communications technology or with the volume of information available to use, but it has everything to do with human limitations," says David Orr. "What ails us has less to do with the lack of knowledge but with too much irrelevant knowledge and the difficulty of assimilation, retrieval, and application" (Orr 2002).

Slow processing speeds are partly linked to the brain's difficulty retaining unfamiliar information. Information is most quickly retained when the brain has the contexts to help assimilate new data into existing information stores (Seidel 1998). For example, an architect is more likely to retain new information about a new type of insulating material than an accountant with no surrounding context to link that information with. The accountant might recall the information about the insulation for a short period of time, but unless reinforcing context and reminders are provided, it will most likely quickly fade and be replaced with other information (Seidel 1998). This condition points to the importance of both 1) relating new information to existing frameworks and familiar contexts of everyday life, and 2) creating living contexts that enable people to assimilate and process new environmentally-related information.

New information also requires simplification to be successfully internalized and retained. Scientists, engineers, and other professionals often use statistics and numbers to measure and communicate important environmental indicators such as the amount of carbon dioxide released into the atmosphere or the amount of electricity produced by a photovoltaic system. Unfortunately, however, most people lack the contexts and scale to give these figures any meaning (Seidel 1998). For example, providing kilowatt-hour (kWh) data on an energy bill is worthless unless people know how much a kWh is and what actions consume a kWh worth of energy. Therefore, for this type of data to impact people's attitudes, it must be translated into easily understood and absorbed terms.

If the brain receives complex information that requires further simplification, it often oversimplifies to a point where the original information becomes misconstrued or distorted (Seidel 1998). "The fact remains that we are not perfect information processors," says E.N. Anderson. "We make mistakes…we have to approximate. Many of the simplifying assumptions…are necessary if we are to operate in a complex world. Unfortunately, they also lead us to oversimplify and over generalize in dealing with the environment" (Anderson 1996). Falsely believing distortions to be accurate, people form attitudes based on misconceptions (Seidel 1998).

***Diffusion of Responsibility.*** Humans seem to exhibit a strong tendency to diffuse responsibility for both causing and solving societal ills (Orr 2002). Public opinion surveys suggest that people believe that addressing environmental problems is the duty of larger social institutions (such as government, industry, schools, etc) rather than individuals (Farhar 1994). The fact that many environmental problems result from the additive impacts of millions of small actions makes them particularly vulnerable to diffusion of responsibility. People often believe that the impact of individual acts of stewardship, such as conserving energy or recycling, are so minimal that making any effort at all is meaningless unless it is clear that everybody else is participating (McClelland 1981). This classic social trap results in individuals failing to take personal responsibility for their own actions; a condition that points to the importance of creating residential developments that instill a sense of personal and community accountability for stewardship.

***False Optimism, Denial, and Distrust.*** Large societal problems with frightening implications can ironically evoke emotions of cynicism and denial which result in apathy toward huge and seemingly unconquerable issues (Smith 1999). False optimism, also known as "positive illusion", is a form of denial that manifests itself through rationalizing expressions such as "there is plenty of oil left", "leaving the lights on doesn't waste that much energy," or "there is no way that they would allow the landfill to contaminate my water" (Anderson 1996). False optimism is largely perpetuated by disconnection and difficulty processing information. "The more one can avoid hard facts and other real-world feedback," says E.N Anderson, "the more one can self-delude" (Anderson 1996).

Reactions of denial and false optimism are tightly associated with information source credibility and distrust. People are particularly skeptical of sources that appear to hold some kind of personal agenda. For example, a New York City study showed that individuals receiving energy conservation advice from the non-profit NY State Public Service Commission were more likely to alter their energy consumption patterns than those receiving identical advice from the for-profit local utility company (Craig 1978). Similar results came from a Minnesota study in which a local county authority was far more successful at convincing residents to conduct home energy audits than a private auditing company (Stern 1986). Some individuals are equally hesitant to trust environmentalists; a group often perceived as having elite special interests that ignore the general interests of the population.

Information sources can also be discredited if an individual's personal experience fails to support the information they have received. For example, if residents are told that reducing their thermostat by one degree at night will save them ten dollars per month, but the savings are masked in the energy bill by other factors (such as running extra laundry loads or a change in weather), the information source will lose some credibility (McClelland 1981). Issues of denial, distrust, and credibility points to the need for creating opportunities that enable people to formulate their own attitudes based on personal experience rather than being forced to rely on somebody else's word.

***The Attitude and Behavior Disconnect.*** Many people report holding values of environmental stewardship, yet their behaviors fail to reflect those attitudes. For example, a study found that while participants in an intensive energy behavior education workshop reported significant increases in their understandings and concerns about energy conservation, their knowledge failed to correlate with any increase in energy conserving actions (Geller 1981). How can this disconnect be explained and addressed?

Fishbein and Ajzen's *Theory of Reasoned Action* (Fishbein 1975) states that new attitudes do not necessarily result in new behaviors (Black 1985). However, several conditions help facilitate the translation of attitudes to behaviors. These conditions are critical to developing design strategies that engender new attitudes which carry into observable behaviors of environmental stewardship.

- *Attitude Strength.* The more powerfully people hold onto a particular belief, the more likely they will act on that belief. Attitudes formed from credible sources and specific first-hand experiences tend to be stronger than those shaped by vague general advice and information (Bell 1996b). For example, individuals who take part in energy audits rather than simply being told results of the audit, show a greater tendency to change their behavior (Stern et al. 1984).

- *Attitude Accessibility.* Attitude accessibility means that people must be consciously aware that they hold a particular attitude before they act on it. In other words, to act on an attitude, you must be able to think of that attitude (Bell 1996b).

- *Attitude Relevance.* Even if one is aware that they hold a particular attitude, they must understand that their attitude applies to a specific situation in order to act on it (Unknown Author 1996). With environmental issues, this requires an individual to understand why, when, and how to act upon an attitude given a particular situation. For example, a person will not recycle if either they do not know where to recycle, or if they fail to realize that recycling can be beneficial for the environment.

- *Perception of Control.* An individual's perceived control over a situation strongly influences the likelihood that he or she will act based on a held attitude. Perception of control involves creating the physical means to carry out a particular action. For example, an individual might lack a perception of control if she wants to recycle a can, but has no recycling bin readily available (Bell 1996b).

- *Degree of Impact.* The more an individual believes a particular action will impact a situation, the more likely one will perform that action (Bell 1996b). For example, a person is more likely to recycle if they sense that it will really make a big difference in reducing the amount of waste sent to landfills.

***Self-Interest.*** A final explanation for individuals' lack of environmental stewardship stems from the human tendency to act out of self-interest. People's basic evolutionary instincts create a drive to first and foremost take care of themselves, family, and immediate interests in order to survive an already challenging world (Parnell 2005). Unfortunately, environmental stewardship is often perceived as requiring self-sacrifice but providing little or no personal individual benefit in return (Parnell 2005).

The ecologist and biologist E.O.Wilson suggests that the drive to act out of self-interest is enmeshed in a dilemma of two competing values sitting at the core of human existence: altruism and self-preservation (Wilson 2004). Faith that pure altruism will motivate environmental stewardship in the majority of the population is unrealistic, but it is equally foolish to assume people are entirely free of altruistic motivations. In fact, there is a "growing body of evidence that people's dedication to saving the environment can lead at least some to forego selfish benefits, assume personal responsibility, and endure personal sacrifice in order to promote conservation of the environment" (Bell 1996b). However, Wilson hypothesizes the majority of the population reconciles these two competing drives through a "soft" altruism, or selfish altruism (Wilson 2004). Soft altruism involves reaching self-serving ends through altruistic means. Thus, linking environmental stewardship with "selfish" personal benefits, such as convenience and improved quality of life, could provide a pathway for learning intrinsically motivated stewardship behaviors (Stern 1993).

### *Conclusion*

The psychological, behavioral, and cognitive characteristics discussed in this chapter prevent people from individually considering and addressing the environmental impacts of their own actions. Each is negatively reinforced by the current design of our built environment. For example, the tendency to devote less attention to what is not personally experienced is reinforced by communities that disconnect individuals from the negative consequences of irresponsible resource use and mismanagement. Natural resources and systems take on such little relevance in American homes that people possess no context for processing new information that might otherwise be an impetus to alter habits. Even though people are urged to turn off the lights when they leave a room, they are so cut off from the consequences of such an action that they can easily forget, dismiss the plea as merely alarmist and unnecessary, or simply say "who cares?" since "everybody else" seems to leave their lights on and no personal benefit of conservation is readily apparent.

These behavioral qualities describe a deeply entrenched set of barriers resulting from a psychological, physical, and societal evolutionary process spanning thousands of years. However, the ability to recognize these limitations also means strategies can be devised to overcome them. In doing so, the next chapter will examine how some schools and formal academic programs are using place-based environmental pedagogy and supporting facility design to confront these human qualities and engender new attitudes and behaviors of environmental stewardship among students.

# *Chapter III:*

## *Place-Based Environmental Education and School Design*

"Place is a teacher. The dynamic between our minds and our places is powerful. To treat it lightly or without careful attention is a fundamental mistake that is being repeated each and every day by highly respected educators. Even by those of us who teach environmental education."

*-- Rocky Rohwedder (Rohwedder 2000)*

Life is a continuous learning process. People learn about the world through personal interactions with other people, ideas, and surroundings. These interactions take place within a physical setting that builds the contexts for learning and helps shape many values, attitudes, and behaviors. Therefore, if one wishes to design places that confront ingrained human qualities and instill new behaviors reflecting environmental stewardship and responsibility, then physical surroundings must be conceptualized as immersive learning environments. Hence, the "pedagogy" of pedagogical design.

Residential homes and communities rarely take advantage of the teaching power held within the built environment. Many schools and universities, however, have discovered techniques for using physical contexts as means for advancing their environmental missions. This chapter aims to identify strategies that can be transferred from academic to residential contexts. It begins by exploring the theory behind place-based environmental education; a relatively new pedagogical approach that has demonstrated effectiveness in instilling an environmental ethic among students. It then identifies key strategies used to shape place-based academic programs and facilities that can inform the development of a pedagogical design framework for residential contexts.

### *Place-Based Environmental Education Theory*

The theory behind place-based education is grounded in an assumption that individual environmental disinvestment is perpetuated by a general disconnection to, and lack of caring for, home communities and local natural contexts (Gruenewald 2003). While place-based education does not speak explicitly of the human qualities that were highlighted in Chapter II, it implicitly addresses all of these conditions by focusing directly on the disconnection between people and their physical contexts.

While many environmental education programs emphasize global issues such as exotic species extinction, rainforest destruction, and global warming, place-based educator David Sobel contends that individuals will not modify their behaviors to solve such inaccessible, "out of sight", and intimidating problems (Sobel 1996). Rather, individuals need to address issues that immediately impact their own lives and communities before they can effectively act at larger scales (Sobel 2004). Unfortunately, people often fail to recognize that homes and the surrounding built and natural environments are special, unique, and worth protecting. People assign the concepts of "nature" and "special places" to national parks, exotic vacation spots, or locations profiled on television programs, while their own neighborhoods are perceived as faceless, "everyday places" (Lewicki 1998). This perception feeds a cycle of further environmental disinvestment (Gruenewald 2003). For example, when people are disconnected from the natural resources and character of their community, it becomes easier for generic, resource inefficient, and ecologically destructive development patterns such as fast food chains, tract homes, and big box stores to take hold. Such development patterns further mask the uniqueness of "everyday places", and perpetuate greater disconnection between people and their place. However, beneath the generic development patterns characterizing so many American communities today, these "everyday places" contain unique resources, people, geographic and ecological features, and history that make them special. Place-based educators believe that when people experience these elements on a regular basis, it triggers a desire to protect and steward over them (Lewicki 1998). While place-based education aims to stimulate stewardship of all of these elements as a whole, local natural resources, systems, and habitats comprise the specific focal point of environmentally-oriented place-based education.

In order to create a strong desire to protect natural resources and systems, place-based environmental education involves a strong appeal to human emotion; a sharp contrast to both the information dissemination and rational decision-making models that traditional education and economic incentive paradigms employ to influence behavior. Stirring an emotional bond with natural contexts is critical for creating an emotional drive to protect them. "Any management strategy that does not take human feelings into account simply will not work...," says E.N. Anderson. "...We know, more or less, how to manage the resources—at least how to conserve them. The problem is how to motivate people to do it. Motivation is an emotional matter. Knowledge is necessary, but knowledge without an emotional drive does not produce action" (Anderson 1996).

### *Key Strategies for Implementing Place-based Theory in Academic Settings*

The theory behind place-based environmental education is implemented in academic settings through a number of concrete teaching and learning strategies. Each strategy explained below is followed with examples of how schools have translated these fundamental concepts into the design and programming of educational facilities that support each particular strategy. These pedagogical and design strategies are interrelated and supportive of one another in creating the conditions that give students the power to be better environmental stewards.

***Lessons Demonstrate Natural Limits***. Many educational approaches employed in schools send a strong message to students that "with enough knowledge and technology we can manage planet earth" (Orr 1991). Often this message is communicated by approaching environmental threats through scientific analysis and social policy designed to solve problems "through the collection of better data, the framing of regulatory legislation, or the development of institutional procedures aimed at reducing waste" (Smith 1999). This approach may be partially responsible for inspiring a "false optimism" that technological and economics based approaches can completely solve environmental problems.

Alternatively, place-based education urges students to reshape their own desires to match natural limits, rather than attempt to reshape the earth to match their needs (Orr 1991). Natural resources are not endless, and even those that are renewable depend on their wise-use in order to ensure that they remain safe and available for human consumption. "The awareness of limits opens us to the fact of our unlimited dependence on a larger order of things that we will never fully comprehend," says David Orr (Orr 1991).

Schoolyard garden plots are a unique tool that place-based educators use to demonstrate limits by exposing students to the process of growing food. "In gardens nature calls the shots," states Janet Pivnick, a proponent of school-yard gardening. "In a garden we must live within the limits of nature instead of forcing it to bend to our will. This requires patience, an ability to listen to nature's wisdom, and develops a respect for nature" (Pivnick 2001). For food to grow effectively, students learn to depend on worms and nutrients to enrich soil, the interdependence of water and sun, and the role of insects and pollinators in assisting growth cycles.

Energy monitoring and on-site renewable energy technologies are another way of demonstrating nature's limits in generating energy resources. The Environmental Technology Center at Sonoma State University utilizes a large "Net Electric Meter" that "dramatically illustrates the effect of solar generation by spinning backwards" whenever photovoltaic production exceeds the building's consumption (Janda 2005). The meter moves at different speeds, illustrating that energy production is highly dependant on natural forces such as weather, season, and time of day.

***Lessons stress connections between students and natural contexts.*** Place-based learning is an integrative, interdisciplinary pedagogy that studies the relationships between natural systems such as nutrient, water, and energy cycles, and human systems such as cities, politics, and resource extraction (NAAEE 2006). Lesson content provides students with "ecological literacy" – a body of knowledge encompassing the earth's physical systems, local and human ecology, the natural history of one's own region, and strategies for restoring local natural systems, communities, and economies (Orr 1991). Helping students understand their personal dependence on natural systems strengthens their relationship to the natural environment and those resources which support them (Lewicki 1998).

While the typical classroom "limits, devalues, and distorts local geographical experience" (Gruenewald 2003), place-based lessons take place in physical settings that create sensory experiences which enable students to feel immersed and connected to their surroundings. Learning about their physical contexts theoretically helps students "recognize its beauty and then take the steps needed to guard its integrity" (Smith 1999). In many ways, the effects of a "typical" classroom are comparable to a "typical" housing development or unit. Homes built in Denver are often identical to those built in Miami, Dallas, or Seattle. They respond primarily to economic contexts, while "devaluing" and "distorting" the ecological contexts that connect people to a place. As a result, occupants know nothing about their natural surroundings. "If we have little understanding of the communities and ecosystems in which we live," says Timothy Beatley, "we will perceive little visceral or personal connection to them, tend not to care about them, and have little sense of what actions, behaviors, or policies will be necessary to nurture and steward over them" (Beatley 2004). Place-based education strives to make students keenly aware of these connections.

To support their curriculum's stress on interconnections, ecological literacy, and understanding ecological contexts, some schools that utilize place-based approaches have redesigned their physical facilities. For example, some primary and secondary schools have replaced asphalt and turf playgrounds with small yet functional local habitats containing a range of plant species that attract birds, butterflies, and other small wildlife creatures (Grant and Littlejohn 2001). This "naturalization" of schoolyards and playgrounds allow students to learn from native landscapes regardless of the school's urban or rural character. Urban students who have never seen wildflowers bloom or bumblebees pollinate can experience the original biotic heritage of their community and see that the world is composed of more than concrete, asphalt, and people, while suburban students can learn that "nature" is not the same thing as turf grass. "Landscape is at the core of bringing a wider understanding of environmental capacity. Landscape design can help educate people about the complex dependencies present in the environment" (Edwards and Turrent 2000).

Depending on the ecological character and climate of a school, naturalized schoolyards can incorporate a variety of landscape features that stress connections to:

- *Water and Wet Areas:* Streams, ponds, rivers, creeks, and marshes provide habitat for turtles, fish, frogs, birds, and other small animals, and illustrate lessons of storm water retention, drainage, filtration, and water recycling (Knoop 2001). Water is a highly visible element that creates strong sensory connections through sight, sound and smell, a fact that naturally draw people to landscapes with water (Cheskey 2001).

**Figure 2. The restored wetland at the Lewis Center for Environmental Studies at Oberlin College evokes the site's natural history and demonstrates the ecological functions of wetlands.**

**Image source: http://hpb.buildinggreen.com/**

- *Woodland Environments:* Trees provide habitats for birds, squirrels and other small animals. Forests teach lessons of ecological succession, pollution filtration and photosynthesis, air quality and oxygenation qualities of plants, and transition of seasons (Knoop 2001). Forests also provide sheltered sitting and resting areas, and a wide range of organic materials such as plants, nuts, soil, leaves, and other natural objects on the forest floor for students to interact with and explore.

- *Grasslands/Meadows/Prairie Habitat*: Grasslands, meadows, and prairies habitat attract a wide variety of birds and wildflowers, and provide a safe setting for student exploration and interaction with natural contexts. Walking paths can lead students on guided "learning walks". Strategically placed feeders and nest boxes can help attract birds to locations that students can observe (Knoop 2001).

**Figure 3. A schoolyard transformed to represent the native prairie landscape.**
**Image source: www.artandlindaswildflowers.com**

- *Brush Piles and Hedge Rows:* Rather than dividing off sections of schoolyard using fences, planted brush and hedgerows can serve the same purpose while simultaneously providing food and cover for small animals. Hedge rows may be used to block wind, provide shade, and demonstrate how designed microclimates can increase comfort levels for outdoor recreation areas (Knoop 2001).

- *Boulder Fields*: Boulders and rocks provide places for sitting, climbing, or exploring and provide habitat for a variety of small creatures such as worms and insects that attract both birds and kids (Knoop 2001).

- *Roof Gardens:* Schools without sufficient outdoor space can transform their roof into an outdoor learning space. Roof gardens can demonstrate storm water capture and run-off principles, attract wildlife, and provide a medium for exploring the principles and benefits of green-roofs (Knoop 2001).

**Figure 4. Rooftop learning landscapes. Image sources: www.lcherbalists.co.uk (left), chicagowildernessmag.org (right)**

**Figure 5. A school before (above) and after (right) schoolyard naturalization.**
**Image source: Canadian Biodiversity Institute.**
**http://www.biodiversityonline.ca/**

Schoolyard naturalization emphasizes a connection between students and non-human species; a strategy attributable to E.O. Wilson's "Biophilia Hypothesis". The Biophilia Hypothesis states that humans innately desire a connection with other species. "Humanity is exalted not because we are so far above other living creatures," states Wilson, "but because knowing them well elevates the very concept of life" (Wilson 1984). If the Biophilia Hypothesis is true, then plants and animal wildlife hold the potential to engage students and enhance connections to a community's natural contexts.

Another design strategy that enhances connections to natural contexts are facilities that seamlessly connect outdoor and indoor space to give students a greater awareness of their surroundings, and highlight observable changes in weather and outdoor light. The Lewis Center for Environmental Studies at Oberlin College explicitly utilizes this principle by creating views from all offices and classrooms to a restored pond, wetland, and small forest that evoke the site's biotic past. "From that vantage point, the feeling is one of openness to the nature beyond—light in all seasons," says David Orr, who spearheaded the construction of the Lewis Center and works in the building (Orr 2006).

**Figure 6. The atrium of the Lewis Center connects indoors and outdoors to give occupants a strong sense of their surroundings. Image source: http://www.eere.energy.gov**

Other design strategies that draw connections between students and natural elements include windows that help students track the angles of the sun (Taylor 1997), and sundials and prisms which compliment lessons on sunlight and solar energy (Innovative Design). Oberlin's Lewis Center utilizes an indoor Living Machine, a system of tanks containing plants, fish, bacteria, and other organisms, that turn 100% of the building's wastewater into reusable grey water (Oberlin 2000). Unlike conventional waste treatment which takes place "out of sight and out of mind," Living Machines demonstrate how natural processes break down water contaminants without chemicals. The only byproduct of the process is an organic biomass material which students can apply to gardens as compost or fertilizer – thus revealing the workings of the nutrient cycle.

**Figure 7. Living Machines demonstrate how human waste can be broken down using natural processes. Image source: http://www.findhorn.org/photos/ecovillage**

Studies have shown that cultivating connections to natural contexts is critical for instilling a greater sense of emotional connection and environmental awareness. Childhood exposure to natural environments has been linked with the development of reverent attitudes for nature. One study found that "many hours spent outdoors in a keenly remembered wild or semi-wild place in childhood or adolescence, and an adult who taught respect for nature" were the primary motivators of positive environmental attitudes as an adult (Sobel 1996). In 2000, researchers at the Education Development School Center in Newton, MA conducted a study showing a correlation between positive environmental attitudes and replacing asphalt school yards with naturalized playgrounds (Sobel 2004). This finding supported a 1989 British study that showed as the "diversity of the natural landscape on school yards increases, there's an increase in children's appreciation of experiences in the natural world" (Sobel 2004).

***Lessons utilize experiential learning principles.*** Didactic classroom lectures model that learning is a passive activity of information absorption that takes place inside the classroom, separate from the activities of the outside world (Orr 1991). "Strategies which make people into mindless, passive sponges for information, are counter productive" (Anderson 1996), because lessons can appear irrelevant to a student's everyday life. Such strategies merely reinforce people's natural difficulty focusing our attention and processing non-relevant or new information.

Alternatively, place-based education relies heavily on direct experiential learning by having students acquire knowledge through a process of doing, experiencing, exploring, and discovering (Wikipedia 2007). Place-based education integrates active learning into students' daily experiences to demonstrate the ecological impacts and consequences of everyday activities (Smith 1999). Information attained through direct experience is more likely to relate to existing psychological contexts, thus increasing the chances is will be processed and retained (Parnell 2005). First hand experience also enhances the credibility of new information – students believe what they experience themselves. Chapter II stated that high credibility and relevant information combine to form stronger, relevant, and more accessible attitudes more likely to translate into behaviors. This conclusion is supported by a study of environmental programs showing that those utilizing active learning principles resulted in greater environmental stewardship than those which did not (Zelezny 1999).

An example of a lesson that incorporates active learning involves a program that integrates schoolyard gardening and school lunches. Organic lunch wastes are collected and composted in bins for use as garden fertilizer (Audubon International 2005). The compost helps fertilize schoolyard gardens that produce food for school lunches. This program demonstrates to students how natural systems (in this case the nutrient cycle) intersect with their everyday lives (lunch time), and specifically reveals that food does not come from invisible sources, that waste does not disappear into an endless void, and that what ends up in the ground can end up in your food. Students learn these lessons as part of an activity they do normally every day—eating lunch—a context which helps attach greater meaning and relevance to their learning.

**Figure 8. Students measure the temperature of a school yard compost heap that fertilizes their garden. Image source: www.audubon international.org**

***Learning settings foster interaction, inquiry, and discovery.*** "Environmental education is about what the environment can teach all of us as well as what we can teach each other about the environment," says Sonoma State University Professor and place-based education proponent, Rocky Rohwedder (Rohwedder 2000). To maximize the teaching potential of the physical environment, students should be able to engage and interact with their surroundings in such a way that enables manipulation, exploration, and questioning of surrounding contexts (Cheskey 2001). Such interaction fosters experiential learning, first-hand experience, and their associated benefits. "People…are motivated to learn, to discover, to explore," says University of Michigan Psychology Professor Stephen Kaplan. "They prefer acquiring information at their own pace and in answer to their own questions" (Kaplan 2000).

Many school buildings are designed to "stimulate curiosity and serve as a study tool" (Taylor 1997) through architecture that demonstrates environmental principles and highlights certain features of the natural environment. For example, some schools expose their cooling and heating systems for study (Taylor 1997), energy-efficient building components are designed to make their function obvious, and wall and glass treatments on different building facades emphasize the reasoning behind different solar design responses. In addition, corridor walls and displays teach local history and display student artwork, artifacts, and cultural displays (Taylor 1997). Naturalized landscapes also spark inquiry by giving students an opportunity to interact and explore the landscape.

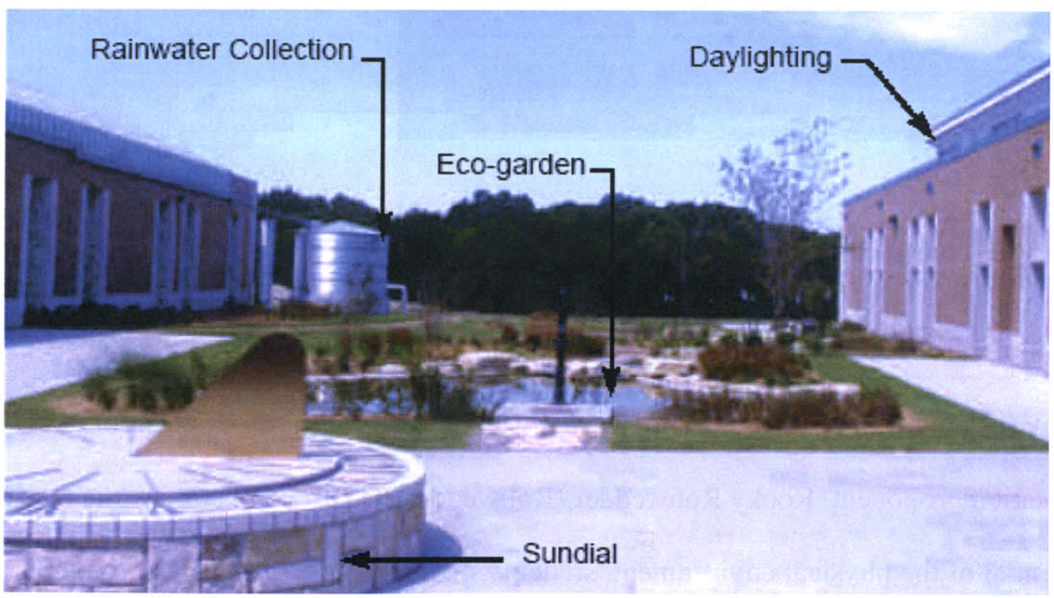


**Figure 9. Certain elements of schools are designed to prompt students to ask, "What is this for?" This school in Texas uses familiar vernacular imagery, such as the metal grain silos, as context to introduce new ideas related to rainwater collection and recycling. Image source: Innovative Design.**

Pedestrian paths, sitting areas, and opportunities for interaction nested within plants, rocks, and habitats promote student exploration, manipulation, questioning, and interaction with the environment rather than passive observation (Innovative Design). Design elements, such as those seen in Figure 9, prompt questions and enable students to discover clues for hypothesizing answers to those questions (Cheskey 2001). Utilizing familiar concepts and contexts to introduce new concepts helps avoid confusion and disorientation.

***Emphasis on community development.*** Education is often framed as a vehicle for personal advancement and achieving economic success. As a result, lessons and curricula that reflect this purpose reinforce individualism and self-interest—attitudes that propagate ecologically degrading behaviors (Gruenewald 2003). In contrast, place-based education emphasizes the importance of building social connections, community, and an individual sense of responsibility to the larger group. "The purpose of community, the society of learners in a school, is to serve and support others," says place-based educator James Lewicki. "Teaching without paying attention to community-building is like sailing without a sail" (Lewicki 1998).

This emphasis on community development and interpersonal relationships aims counter people's tendency to 1) act out of self-interest, and 2) diffuse responsibility for stewardship to others. It is also critical for establishing peer networks capable of transmitting positive attitudes toward environmental stewardship, creating a supportive social atmosphere in which efforts to address socio-environmental problems are lauded and reinforced, and empowering students to tackle environmental issues as a group

(Smith 1999). A strong sense of community helps people "embrace the experience of being human in connection with the others and with the world of nature, and the responsibility to conserve and restore our shared environments for future generations" (Gruenewald 2003).

In academic settings, teachers build peer relationships and develop students' sense of the meaning of "obligation, responsibility, and support associated with those relationships" (Smith 1999) though intimate class sizes, opportunities for leadership development, and chances for peer to peer informal interactions outside of class that build a feeling of social membership (Lewicki 1998).

Demonstrating that students are part of a broader community outside of school is equally important. "Education for sustainability must involve everyone…," reported the 1996 Presidents Council on Sustainable Development. "…[it] should reach beyond school walls to involve parents, industry, communities, and government in the education process" (Lewicki 1998). To do so, schools seek out community partners capable of contributing resources, curriculum, or internship/service-learning opportunities (NAAEE 2006). Service learning provides students with an opportunity to "make a difference" locally, engenders relevant and experiential learning experiences, enables students to educate the larger community, and facilitates the development of social networks focused on addressing environmental issues (Lewicki 1998). Such programs

**Figure 10. Service-learning provides an opportunity for students to learn how to make a difference in their local community. Image source: http://www.earthactionfest.org/**

range from group tree plantings or river clean-up days, to planning landscape restorations or conducting water quality testing for local environmental jurisdictions.

Schools are also increasingly designed as community centers that invite in the greater community and "break down the invisible barriers that formerly existed between schools and their surroundings" (Taylor 1997). While it is common for school library and fitness facilities to be open for public use, a school's ecological amenities and ecological learning opportunities, such as gardens, living machines, naturalized landscapes, and renewable technology exhibitions may be made accessible for public education. For example, Northwest Missouri State University has received more than ten thousand visitors to tour their biomass energy plant (Cole 1995), a fact that not only helps spread the importance of renewable technologies, but also demonstrates to students that the larger community values and has an interest in their unique renewable energy source.

***Technology is a critical learning tool.*** Place-based environmental education aims to give students proficiency with technologies that display, analyze, and communicate environmental information. This enables students to observe, measure, and monitor elements of a specific place that they would otherwise not perceive with their senses alone (NAAEE 2006). Such technologies include environmental sensors and control mechanisms, real-time interpretive displays of environmental information, and a variety of computerized tools which can help forge stronger connections to resources and give significance to otherwise incomprehensible or invisible data.

The Lewis Center for Environmental Studies at Oberlin College includes 148 data sensors located throughout the building that collect data on energy and material flows on a real-time basis. Information from these sensors, including data on PV production and consumption, energy flows and power use distribution (lights, plugs, appliances, HVAC, etc), and percentage of power use from renewable and non-renewable sources, is all displayed on the college web site and in the building's lobby (Oberlin 2000). This information allows students to perceive the actual amounts of energy their actions demand.

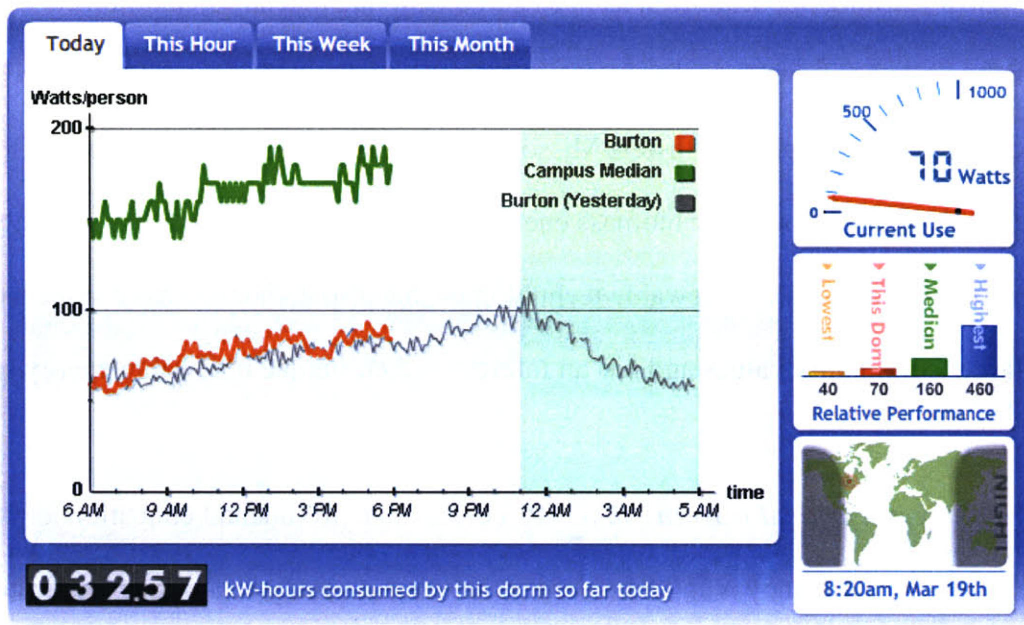


**Figure 11. Web based building resource monitoring systems give students a new understanding of their energy use in classroom buildings. Image source: Lucid Design Group, LLC and Oberlin College**

Renewable energy systems are another form of technology that can strengthen connections to resources. Some schools have chosen to site renewable energy systems in highly visible locations to serve as sensory reminders of the school's energy source. For example, in addition to a 59 kW rooftop PV array at the Lewis Center, a low parking shelter adjacent to the building includes a 100 kW PV system that is highly visible from

**Figure 12. A mixture of highly visible renewable technology can demonstrate alternatives to fossil-fuel energy sources. Image source: http://news.dri.edu/**

within the Lewis Center (Orr 2006). Incorporating a wide range of visible renewable energy technologies such as solar hot water heating, wind mills, and photovoltaic panels reveals the range of energy sources available to people in addition to standard fossil fuels. Monitoring systems can demonstrate the climatic, weather, and seasonal conditions that facilitate optimal energy production (Innovative Design).

Other technologies that reveal environmental information include control mechanisms such as daylight sensors, occupancy sensors, and automatic shut-offs. These types of automatic control systems activate when resources are being used unnecessarily to demonstrate that that resources should not be wasted.

***Educational Institutions Lead by Example***. Proponents of place-based environmental education emphasize the importance of leading by example, modeling attitudes and behaviors for environmental stewardship, and sending a consistent message to students. Actions speak louder than words, so educators and institutions must avoid appearing hypocritical by practicing what they preach (Rohwedder 2000). For example, Rocky Rohwedder argues that despite preaching the importance of recycling and waste conservation, most practices at schools send the message that "it's OK to use lots of stuff inefficiently and then just throw it away'" (Rohwedder 2000).

Leading by example can take two primary forms: 1) messages sent through the actions of individual faculty and staff, and 2) messages sent through a building's design. In the first form, school faculty should model the attitudes they hope students will adopt. For example, if students are taught that energy is a precious resource, teachers should practice energy conservation in the classroom. If students are taught to avoid polluting toxins, maintenance crews should not use toxic cleaning solutions.

The second form of leading by example requires institutions to design facilities that explicitly demonstrate a commitment to their environmental values. "Consider your own environmental/outdoor school or center. What lessons does it teach?" asks Rocky Rohwedder. "Do your facilities and grounds clearly demonstrate environmentally-sound choices in building design and operation? For example, when students visit your place do they see buildings which are well insulated, lit by daylighting and energy-efficient lights, heated and cooled through passive solar design, and operated with energy-efficient and water-efficient appliances? Do they see edible landscapes and drought-tolerant native plantings? Is the food you eat and serve grown locally and organically? Is your place a model of the three R's – reduce, reuse and recycle? If you can't answer most of these questions with a solid Yes!, then what's the real message you give to those who come to learn from you and your place" (Rohwedder 2000).

Leading by example has three primary benefits. First, observing environmentally responsible behaviors, such as switching off lights when leaving a classroom, on a regular basis can remind students about the importance of such practices. This could effectively prompt for similar attitudes and behaviors. Second, students might be encouraged to adopt a particular behavior if they perceive that their efforts are lauded and supported by the larger community. Lastly, if students sense hypocrisy, the credibility of both the institution and the messages it sends will suffer. As a result, the believability and impact of their lessons could be reduced (Orr 2004).

### *Conclusion*

While very little hard data exists on the effectiveness of place-based environmental education, educators who have been personally involved in these programs attest to their power. "We have seen…members of a community transformed as a result of their participation in a 'place-based' environmental education," says David Sobel. "They inevitably come away with a far deeper sense of the natural and cultural web of life that defines their communities. This is a web that binds the generations and reinforces our sense of responsibility toward our places…it reveals to us our own uniqueness as well as our connectedness with all life. Nature literacy, we believe, can rebuild communities" (Sobel 1996).

The exploration of place-based environmental education in this chapter has demonstrated several means for creating academic programs and facilities that advance behaviors of environmental stewardship and responsibility among students. This knowledge can now be transferred into residential contexts. The final chapter will synthesize human behavioral qualities with the strategies of place-based education in order to establish design and programming guidelines for residential developments using a pedagogical design framework.

# *Chapter IV:*

## *Pedagogical Design for Residential Development*

"We shape our buildings, and afterwards our buildings shape us."

--*Winston Churchill*

This chapter synthesizes the information gleaned from examining human behavioral qualities and place-based environmental education into a set of guidelines for designing and programming residential developments from a pedagogical design perspective. Following these guidelines, a descriptive scenario illustrates the potential that housing developments possess to enhance people's connections to natural resources and systems, and build the contexts for more judicious and responsible resource use.

Although many differences exist between academic and residential contexts, place-based environmental education offers a solid model for informing a residential pedagogical design approach. Like schools, homes and communities are ultimately places of learning. People naturally absorb information from surrounding physical contexts, the attitudes and actions of neighbors, and personal daily habits and routines. Currently, residential housing developments in the United States teach residents that disconnection from natural systems is acceptable, that using resources wastefully is inconsequential, and that individual actions contribute little to both creating and solving environmental problems.

To reverse this trend, homes and neighborhoods must emotionally connect people to natural contexts and local environments, remind people to use natural resources judiciously, and show people that individual actions DO make a difference.

*A Pedagogical Design Framework for New Residential Development*

The following guidelines comprise a basic framework for thinking about designing residential developments using a pedagogical design perspective. They are intended to serve as a springboard that enables designers to expand upon this approach with both new guidelines and new strategies to achieve the intents of these guidelines. The pedagogical design framework consists of six guidelines:

1) Establish strong sensory connections to immediate natural contexts and resources.

2) Use technology to extend human sensory abilities.

3) Design interactive environments that facilitate experiential learning in everyday life.

4) Link opportunities for enhanced environmental connection with increased quality of life.

5) Explicitly demonstrate that the developer and/or landlord care about environmental stewardship.

6) Lay the foundations for the formation of a strong community that addresses environmental threats together.

Each guideline is presented individually. However, they should be read collectively as an interrelated and integrated whole. In the detailed descriptions that follow, each guideline is accompanied by simple design and programming strategies that illustrate how its intents might be achieved in an actual housing development. More examples may be found in the illustrative scenario that follows the guidelines, and in Appendix I.

***Guideline #1: Establish strong sensory connections to immediate natural contexts and resources.*** Humans are ultimately sensual creatures that instinctively read and interpret messages communicated by built and natural contexts. "Landscape has meaning…shaped by what senses perceive… Any organism with senses has the potential to read and understand landscape," says Anne Spirn, Professor of Landscape Architecture and Planning at Massachusetts Institute of Technology (Spirn 1998). Places are capable of stimulating the senses to evoke many different types of feelings: feelings of awe and fear, emotions of power or commercialism, sentiments of reverence and respect (Spirn 1998). To encourage environmental stewardship, the places we live should send sensory messages that stimulate feelings of intimate and emotional connection to natural resources and systems. Awakening people's senses to these connections is essential for new understandings and relationships to form and trigger the desire to protect them.

Designers must prioritize finding ways to make visual, aural, tactile, and olfactory sensory experiences a part of residents' everyday lives to…

> …allow people to directly experience the 1) the energy, food, water, and other natural resources sustaining them, 2) the waste flows and infrastructural systems supporting them, 3) habitats and eco-systems surrounding them, 4) history and contexts shaping them, and 5) socio-environmental issues impacting them. These are the elements that make their community unique, beautiful, and worthy of protection.

...continually remind people of the presence and interdependence of natural resources and systems to build more psychologically connected world models.

...build the necessary mental contexts for learning and absorbing information that leads to environmentally responsible behaviors.

Many strategies may be used to achieve these goals. For example:

1) *Preserve or restore natural landscapes and amenities to create opportunities for people to directly experience and emotionally connect with native wildlife and habitats.* Such landscapes can teach people to appreciate non-human species and the ecological niches of certain eco-systems. In addition, visually integrated indoor and outdoor living spaces give residents a strong sense of their surroundings even while indoors. Landscapes and images such as those seen in Figures 13 and 14 are beginning to appear in some "upscale" private homes and suburban developments; the economic premium attached to these homes demonstrates evidence of people's natural biophilic tendencies and desire to feel a bond with nature.

**Figure 13. Wetlands offer a striking contrast to the ecologically sterile backyards offered in many housing developments. Image source: Urban Ecology Australia, www.urbanecology.org.au**

**Figure 14. Integrating indoors and outdoors captures the essence of surrounding natural amenities and increases the connection people experience with their surroundings. Image source: OMR, Architects Inc.**

2) *Install highly visible water, energy, and other infrastructural systems.* Open-channel drainage systems visibly capture, filter, treat, and re-use storm water run-off from nearby roofs and impervious surfaces. Experiencing these processes demonstrates closer connections to the local hydrological cycle, and simultaneously adds to a place's unique character and setting. A stronger relationship to the local water cycle helps build contexts for understanding issues of water quality degradation and depletion at larger scales and in other circumstances. For example, if people see that rain water, drinking water, grey-water, and the water in ponds, rivers, and streams are all connected, then they are more likely to be appalled by the idea of dumping chemicals down the drain or a factory sending untreated effluent into the water supply.

Similarly, installing on-site renewable power generation systems can reveal sources of energy and electricity. Photovoltaic cells, windmills, biomass plants, and passive solar and daylighting techniques are all energy sources that can be designed to demonstrate highly visible alternatives to traditional fossil fuel power sources.

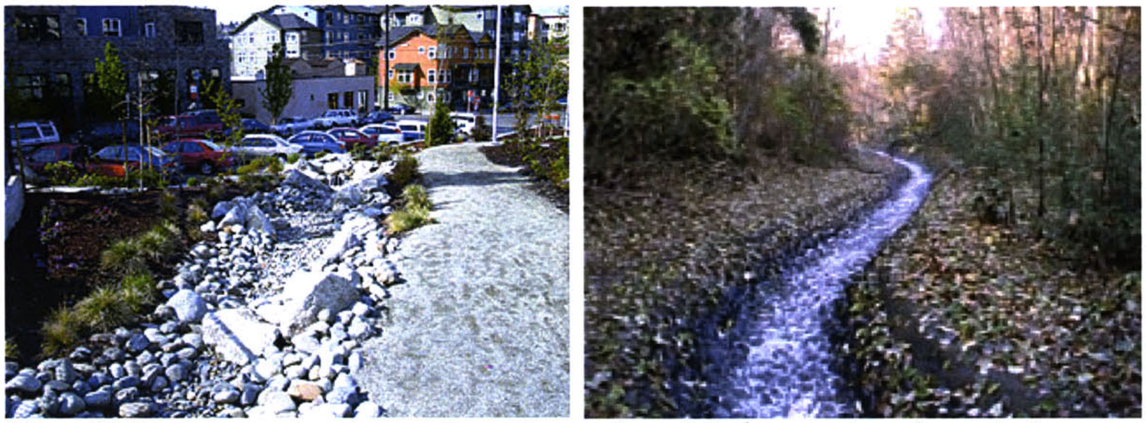

**Figure 15. Storm water runnels, cascades, and open channel-drainage systems demonstrate principles of storm water run-off, soil absorption, and bio-filtration. Image source: www.djc.com (left) and www.city.burnaby.bc.ca (right)**

3) *Create tactile experiences with natural elements.* Gardens offer visual, olfactory, and tactile connections to the soil, nutrient, hydrological, and energy cycles. In gardens, people dig in the dirt, see how things grow, become intimately connected with the land, and gain an understanding for how nutrients, water, and sun combine to sustain living species. People also gain contexts for understanding the connections between food sources and how polluted soil and water can contaminate their own food supplies. Perceiving a dependence on the health of natural processes and systems for survival helps build the strong attitudes that lead to more effective stewardship over these resources.

***Guideline #2: Use technology to extend human sensory abilities.*** An inability to perceive inherently invisible elements, such as energy flows and air pollution, enhances people's disconnection from natural resources and the consequences of natural resource use. Technology can play an important role in expanding human sensory capacities, revealing economic, social, and environmental consequences of natural resource use, and demonstrating the limits of natural resources.

Designers should use technology to…

> …give currently invisible elements that impact people's lives a greater visibility and relevance.

> …provide residents with direct, credible, simplified, and absorbable information concerning details of certain environmental qualities and both individual and community resource consumption.

> …give tangible feedback about economic, ecological, and social consequences attached to personal resource mismanagement and environmentally degrading actions.

Media display technologies and sensing equipment are two technologies that design solutions can utilize to expand human sensory capabilities.

1) *Electronic resource monitoring systems:* Electronic resource monitoring systems measure and calculate both the real-time *quantity* and *quality* of resources that are available to, and consumed by, a resident's individual housing unit and the development as a whole. For example, an energy monitoring system can show the quantities of energy being consumed, and monitor the pollutants in local air and water supplies that might otherwise be missed. This information provides an entirely unseen dimension of the resources connected to a place.

2) *Digital/LED display systems:* Data collected from resource monitors should be displayed prominently throughout the household on LED screens that translate data into relevant monetary or graphical terms that are simple to read, understand, and absorb. These displays allow residents to directly experience their resource intensive actions in a way they can relate to, and to attach real costs to these actions.

Without monitoring and display technologies, an entire dimension of a place's environmental characteristics would otherwise remain unknown. As technology improves, methods for expanding people's sensory capacities will broaden, as will the options for creating interactive environments that are discussed in the next guideline.


**Figure 16. Energy monitors and displays can show people exactly how their electricity is being used in real-time. Image source: http://news.bbc.co.uk/2/ hi/science/ nature/6550361.stm**

***Guideline #3: Design interactive environments that facilitate experiential learning in everyday life.*** Residents should directly experience the relevance of natural resources and systems through their everyday actions and routines. Interactive environments help engage residents in experiencing these relationships.

Designers must create interactive residential environments which…

…catalyze direct learning experiences and inform new attitudes and behaviors through relevant everyday activities and settings.

…continually direct people's attentions toward issues that might otherwise go unnoticed, thus increasing attitude strength, relevance, and accessibility.

…utilize familiar contexts which enable residents to absorb new information.

…provide first-hand, credible information about residents' surrounding environment.

…increase a user's perception of control and degree of impact over a situation.

Strategies for creating interactive environments can be grouped into though three primary approaches: 1) stimulating questioning and discovery, 2) disseminating data and information, and 3) increasing resident control over their surroundings.

1. *Interactive environments spark inquiry and exploration* ***from*** *users.* Unusual, eye-catching, and functional design elements can stimulate residents to question and explore a particular element's purpose, intent, and meaning; thus stimulating an active and self-directed learning process. These elements should 1) offer clues and information that guide an individual's exploration, 2) relate to familiar contexts that enable residents to hypothesize and absorb information without getting confused or disoriented, and 3) enable exploration rather than passive observation.

For example, the Beckoning Cistern (Figure 16) installation on Vine Street in Seattle is both eye-catching and legible. Seeing this unusual object could stimulate curiosity about its purpose. A bit of exploration reveals the connection between one of the cistern's "fingers" and the adjacent building's roof gutter, a familiar context that hints at its use as a rain-water capture cistern. The remaining "fingers" suggest the possibility that more drain pipes will soon connect other roofs to the cistern in the future. This design implicitly communicates that there is some kind of value in capturing and storing rainwater, and makes people wonder about roof water and cisterns – perhaps stimulating further exploration and research.

**Figure 17. Design that prompts inquiry prompts one to ask, "What is this for?" and offers clues that help guide one to an answer. Image source: Beckoning Cistern, 4culture.com**

Glenn Murcutt's Magnie House (Figure 17) in Australia also demonstrates this design approach. The irregular roof design demands attention and exploration. A closer look reveals that the roof guides water into an accented pipe leading to an underground cistern. Rather than mask the water, the pipe allows user's to visibly see it as drains into the cistern. This design reflects the scarcity of potable water in this location, and visibly suggests that the owners use their water judiciously.

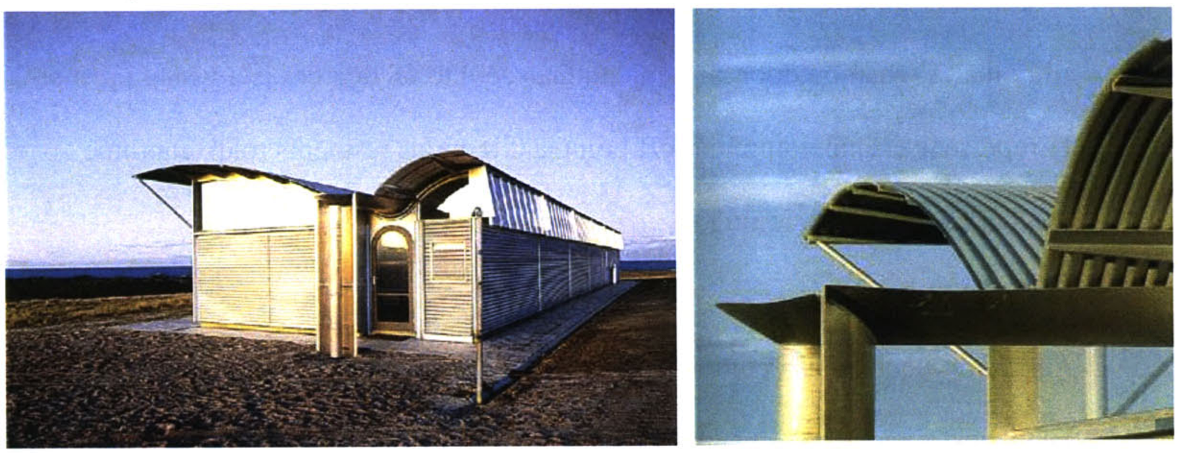

**Figure 18. This integrated roof design and water storage system reflects the need to capture and judiciously use scarce water. Image source: Magnie House, Glenn Murcutt, buildersbooksource.com**

Landscapes may also be designed to foster exploration and inquiry. Manicured, fenced-off landscaping intended purely for aesthetic appeal holds little educational value. However, landscapes that invite interaction with trails, sitting areas, and wildlife offer many opportunities to explore, discover, and emotionally bond with a variety of natural elements comprising the landscape.

2. *Interactive environments disseminate information directly* ***to*** *users.* Residential environments must disburse important data and information directly to residents as

they engage in their daily routines. There are two important methods for disseminating this information:

- *Prompts* are appropriately placed signs, signals, or displays that alert an individual to perform a certain action (McAndrew 1993). Prompts are critical for focusing individual's attentions toward issues that might otherwise be forgotten or go unnoticed. For example, a prominently visible LED light that illuminates when outdoor air temperatures cool to 68 degrees is a visual prompt to represent a temperature cut-off point and reminds residents to discontinue mechanical air conditioning.

- *Feedback mechanisms* communicate information about a user's specific actions. Feedback gives people the ability to monitor their own resource use and connect certain actions to specific consequences. For example, energy monitoring systems can show a user in real-time which specific actions (using lights, running the dishwasher, turning up the heat, etc) consume more energy then others. This enables users to receive direct credible information about the impacts of their behaviors, provides the necessary information to make behavioral adjustments, and allows them to perceive results of behavioral adjustments.

Prompts and feedback mechanisms work effectively together as interconnected strategies. For example, a shower that gradually turns water from hot to cold as a user's prescribed hot water allowance is reached acts as both a feedback mechanism that informs the bather he has used his allotted share of water, and a prompt to end the shower.

3. *Interactive environments give users control over their surroundings.* Control mechanisms, both automated and manual, enable users to apply information from feedback and prompts to optimize the comfort and efficiency of their environment. For example, in response to the thermal indicator light prompt discussed above, users could push one button that simultaneously shuts off mechanical systems, and automatically opens the appropriate windows to create a cross-breeze.

   At the Magnie House (Figure 18), control devices allow users to adjust light, heat, and naturally ventilated air flows to achieve thermal comfort without mechanical systems. Such mechanisms increase a user's perception of control by making it simple to manipulate surroundings to achieve comfort levels and reach resource conservation goals. Most importantly, this environmental interaction makes residents keenly aware of natural processes and systems impacting them. At

**Figure 19. Window shading controls enable users to adjust the amount of light and heat moving between indoors and outdoors. This shows residents that natural daylight and heating can be controlled to effectively substitute for energy consuming electric lights and heating. Image source: Magnie House, Glenn Murcutt, buildersbooksource.com**

the Magniė House, "People adjust windows and walls to admit, intensify, or block light and air flow..." says Anne Spirn, "...and, in the process, they *learn*" (Spirn 1998).

The question of designing control mechanisms to be automated or manual poses an interesting dilemma for designers. On one hand, automated electronic control systems respond to the need for any given process to be made convenient. On the other hand, increased automation can 1) reduce an individual's awareness of the automated process which could potentially lead to some of the issues discussed in the technological paradigm section of Chapter I, and 2) increase the energy consumed versus using purely manual control devices.

As far as the first issue is concerned, it seems automation can be made contingent on some user input. For example, allowing all windows to open automatically at the push of a button offers some level of user interaction, but makes the process convenient. On the other hand, total automation (ie, windows automatically open in response to sensor that indicates certain temperature has been reached) can act as a visual clue that alerts residents to the changing nature of dynamic climatic or weather conditions.

As for the second issue, any increase in energy used for automated controls could potentially be offset by the energy savings that such controls enable. However, this depends on both the goals of a given control system, and equipment used to achieve those goals. Both of these issues raise legitimate questions that require serious study, examination, and consideration on a case-by-case basis.

***Guideline #4: Link opportunities for enhanced environmental connection with increased quality of life.*** Environmental awareness must be shown as a means for increasing quality of life (Parnell 2005). To fully engage residents in acquiring new attitudes and behaviors through such connections, experiences in which learning takes place must simultaneously provide personal health, comfort, economic, recreational, aesthetic, or other lifestyle benefit or convenience that appeals to an individual's self-interest.

Designing opportunities to increase environmental connection and learning through value-adding amenities that increase quality of life…

> …appeals to a resident's sense of self-interest and provides incentive to participate in activities that hold environmental learning potential.

> …improves the mental prioritization and attention given to experiences that hold environmental learning potential.

Each of the strategies discussed to achieve the intents of Guidelines #1-3 offer opportunities for enhanced environmental connections and learning opportunities while simultaneously providing a value-adding personal benefit. For example, energy monitors offer a way to significantly reduce energy costs by enhancing the ease of conservation, and at the same time enable people to become more connected to their energy consumption patterns. Open-channel drainage systems create children's play spots and form a captivating and soothing amenity while revealing lessons of, and strengthening connections to, the hydrological cycle. Gardening facilities offer residents recreational benefits and the opportunity to grow cheap, healthy produce, while simultaneously demonstrating the interdependencies and limitations of natural systems.

**Figure 20. Gardening and open-channel drainage systems provide recreational benefits. Energy monitors make saving money easier.**

**Image sources:**
**shadnet.shad.ca (left)**
**www.bb-environment.org (above left)**
**www.roseville.ca.us (above)**

***Guideline #5: Explicitly demonstrate that the developer and/or landlord care about environmental stewardship.*** Developments must be designed and programmed to demonstrate that the developer, landlord, and/or management staff are invested and committed to environmental stewardship. This models similar values and behaviors for residents, and explicitly shows that the developer is concerned enough about issues of sustainability to invest both the time and monetary resources to address them.

It is critical for designers to demonstrate that the developer is invested in issues of sustainability in order to...

> ...reinforce the credibility of messages communicated to residents. If residents are encouraged to adopt certain environmental values and behaviors, but feel surrounded by contradictory messages, the value of the efforts made to engender stewardship might be diminished. On the other hand, positively reinforced messages can strengthen the value of efforts and set a tone for the entire community.
>
> ...show that a larger entity values, supports, and encourages efforts of environmental stewardship.

Designers can demonstrate the development team's commitment to sustainability by utilizing the following strategies:

1. *Facilitate the implementation of highly visible, ecologically sensitive management guidelines.* Ecologically sound management and maintenance procedures for property managers and maintenance crews should be implemented and marketed to residents. For example, a maintenance team required to use non-toxic "green" cleaning solutions should clearly mark such products as "green" and make them

available for residents' personal use. While designers are generally not responsible for developing maintenance plans, the development's design can foster such programs. For example, space can be provided for residents to purchase the same "green" cleaning products used by maintenance crews from bulk dispensers to clean their own homes. Green maintenance and management practices require a strong commitment to hiring and training property managers who genuinely care about the development's environmental mission, consistently adhere to the guidelines, and continually communicate those values to both employees and residents (Vermeer 2006). They also require coordination between maintenance crews and designers during the design process to ensure that buildings and landscapes maximize the ability of management professionals to maintain and operate the building appropriately.

**Figure 21. Non-toxic cleaning product distribution stations for residents shows that the developer is serious about "green" maintenance. Image source: atlantichospitalityinc.com**

2. *Communicate the developer's environmental ideals through landscape and building design.* The development's design must send clear and consistent messages that reinforce the developer's environmental values. For example, common area lighting that remains illuminated 24 hours/day sends the message that it is okay use resources to power lights when nobody is around. Alternatively, motion activated common-

area lighting fixtures communicate that the developer believed strongly enough in energy conservation and efficiency to install the systems to conserve it.

3. *Reveal the process leading to environmentally responsible design and programming decisions.* Many important decisions that affect the environmental impacts of residents are made during the development process. Unfortunately, these decisions are often not communicated to residents. As a result, an important learning opportunity is lost, and many environmentally significant design features remain unknown. "It's really important to communicate with residents about the things that you as the landlord and developer have done to set an example," says Jane Jones, a Senior Project Manager for the Cambridge, MA affordable development non-profit Homeowners Rehab Inc. "There are a lot of things hidden behind those walls that most people wouldn't know about if we didn't tell them…It's important to explain your process and your thinking." (Jones 2007).

   One critical element of the design process worth revealing is the effort taken to minimize the embodied energy of products and materials used in the construction process. Embodied energy calculations factor the total amount of energy that it takes to produce a given product during resource extraction, production, transportation, and installation. Providing people with this information aids their awareness of the resources that go into everyday household goods, and demonstrates that lowering their personal demand for high-embodied energy products can impact the big picture of resource consumption.

This decision-making process might be revealed is through an exhibit that runs throughout a development's common areas and highlights unique design features, site history, and embodied energy contents. For example, part of a dedicated community room might include a wall cut-away to reveal the insulation, studs, and other systems that help reduce residents' overall environmental impacts. This display might be accompanied by an audio/visual podcast walking tour of the site which explains the site's history, the building's green features, and the physical contexts that played into the design and development process. Appliances, products, and other materials may be labeled to show embodied energy content.

***Guideline #6: Lay the foundations for the formation of a strong community that addresses environmental threats together.*** Many residential developments fail to take advantage of what Bill McKibben calls, "the most useful technology of all, the one Americans have all but forgotten: the technology of community." According to McKibben, existing development patterns have created a "redefined human being, one far more individualistic than before...One who depends very little on neighbors...one survey found that three-quarters of Americans don't even know their next-door neighbors, a novel condition for any human being at any time in history" (McKibben 2007). Unfortunately, the individualism McKibben describes perpetuates self-interested attitudes and diminishes people's perceived degree of impact over large environmental problems. On the other hand, strong communities consisting of strong peer networks can catalyze large-scale engagement with relevant socio-environmental issues.

Designers should lay the design foundations for strong communities to develop in order to…

… nurture the growth of interpersonal relationships that create a sense of duty and accountability to neighbors and other community stakeholders.

…overcome individuals' tendencies to diffuse responsibility to others, and focus on satisfying self interests rather that community interests.

…prioritize environmental threats as issues that must be addressed at both individual and community levels.

…aggregate the efforts of individuals within a community to increase the perceived degree of impact on environmental problems.

The design and programming of residential developments can use several strategies to harness the "technology of community":

1. *Facilitate intimacy and passive social contact to foster relationships through physical planning.* Interpersonal relationships between neighbors are essential to creating a sense of duty and accountability to the larger community. Planning a development to include shared community spaces and resources promote interaction and

interdependence, as does unit clustering and circulation routes that facilitate neighborly interaction. For example, a yard space or gardening area shared between four clustered units will require partnership for upkeep, and creates a setting for neighbors to casually interact. Physical planning to foster community development is a well-studied field that designers should consult before planning any residential development.

2. *Design facilities that encourage social contact through environmentally-oriented "community projects."* Events such as a "Community Clean-up Day" can help bring "people together for a common cause [and] creates a sense of community that is often missing in large and small cities" (Cole 1995). These projects also send messages to residents that show the community holds certain environmental values and expectations. Planning such projects generally falls outside the scope of the designer's responsibility. However, designers can create spaces to accommodate community projects and events. For example, the inclusion of a community room and outdoor space programmed for organizing and holding group events is critical if such projects are to occur. The designer can also push the developer or landlord to consider setting up the appropriate institutional frameworks to spark such projects.

3. *Treat natural resources as shared public commodities.* The individualistic picture that McKibben paints implies that people perceive natural resources as personal rather than shared resources. However, since land, water, air, and energy are community assets, information regarding household resource consumption can be

made public to increase accountability for their use. For example, resource monitoring systems could enable everyone in a community to see how much of a particular resource each household consumes in a given time period. If a community decides to undertake a water conservation program in the midst of a drought, residents will feel obligated to their peers to take part, and have a sense that their water use is being monitored. This will cause people to pay closer attention to how much water they actually use, because nobody wants to be viewed by friends or neighbors as a "water hog" who takes more than their fair share. This scenario can hit on sensitivities regarding the presence of a "big brother" figure, and therefore may not be appropriate in all situations. Utilizing this strategy should be assessed on a case by case basis.

4. *Incorporate mechanisms that maximize the impact of "the power of numbers".* An individual's perceived degree of impact on environmental issues can be increased by aggregating individual efforts into combined results. For example, an individual might not feel that her personal recycling efforts make any difference in the big picture. If she sees her efforts are part of a larger community effort resulting in a sizable amount of waste diverted from landfills, however, her attitudes might change. Therefore, designers should explore integrating technology mechanisms that to aggregate the results of people's individual efforts to transform individual environmental stewardship into a collective endeavor. For example, composted materials, recycled waste, and garbage could be weighed in each kitchen's collection bins as residents separate and dispose household waste. An electronic monitoring

system could track the weight of contents to show residents the combined amount of waste that is collectively diverted from landfills, and demonstrate how individual actions can add up to big results.

5. *Design to integrate with the community outside of the housing development.* Integrating a housing development with surrounding neighborhoods helps plant the seed for building the fabric of stronger communities at larger scales; a critical element for addressing local, regional, and global environmental threats. Community integration may be achieved through partnerships with local organizations that focus residents' attentions to larger socio-environmental community issues; providing physical space for services, amenities, or attractions that are open to the public and draw non-resident's into the development; and through physical planning efforts which emphasize traffic and circulation flows that encourage free flow and interchange with the larger community.

***A Vision of the Future: A Morning in Sunny Marsh***

The scenario below follows the activities of a resident living in the *Sunny Marsh Community* – a large residential development built in a small city engulfed by a major metropolitan region. This narrative presents just a few of the infinite possibilities that can result from utilizing the pedagogical design guidelines presented above as part of an integrated approach for creating greater connection to, and more effective stewardship of, natural resources and systems. The strategies and features referenced within this brief story are described in greater detail the section immediately following the scenario.

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I awoke to the sound of thunder. My room was black, except for my alarm clock which said 3:37am. Luckily it was Saturday morning and I didn't have to get up for work. My shutters were closed to keep my bedroom warm through the cold rainy spring night, but I heard the steady downpour of rain on the roof and smelled the sweet earthy odor of wet soil. It had been almost three weeks since it last rained. The cisterns were running low and the vegetables in the garden were slow to germinate. We needed this rain. I closed my eyes and hoped it would continue till daybreak.

I awoke again at 730am to sunlight on my face. The sky was perfectly clear and my windows had automatically opened to let the morning breeze sweep through my room. Birds sang from the wetlands behind my town home unit. I recognized the sparrow's song that the bird guide from the Audubon Society had pointed out when he came to give residents living in my community, called "The Sunny Marsh", a tour of the avian life in the neighborhood. I laughed thinking about the comment the bird guide made the first time he had come to Sunny Marsh. "It used to be that these communities were named for the landscapes they paved over," he had said. "I'm glad to see yours is named for what it really is!"

I sat up in bed and looked out the long pane of insulated glass that spread across the room's eastern wall. I loved waking up here – it felt like I was outside, perched high in an eagle's nest above the purple and green reeds of the restored wetlands below me with the glimmering city skyline etched across the blue sky. My window faced east, and every morning for the last two months since my wife, son, and I had moved into this condo, we had seen the sun peek its head above the slender high-rise apartments on the horizon a bit more to the northeast each day; the long says of summer were not far away.

As I looked out over the wetlands this morning, the world looked completely different from yesterday. Yesterday the wetlands were almost dry, the tips of plants parched and from a lack of rain. This morning they were nearly flooded. The landscape was alive with the sound of flowing water and the smell of blooming flowers; creeks and storm water channels carried last nights rain steadily into the wetlands. One of the Butternut trees planted at the wetland's edge looked weary and battered; two of its long branches had snapped off and hung lifelessly from the trunk. I saw my neighbor with her seven year old daughter walking across the wooden boardwalk that snaked through the wetlands as they pointed at the ducks and geese that bathed in the morning sun. A Great Blue Heron stood peacefully at the water's edge.

This rain was good news, but I was saddened to think about all of the oil and pollution that was also being swept into the water from the city streets and rooftops. At Sunny Marsh, our landscape was designed to filter these pollutants, but many of the older neighborhoods were not planned with such foresight. I had no idea that water quality was such a critical issue in the city before we moved into our new home here. I was surprised that our water quality monitoring system showed pollution in the wetland and creeks that passed through our community. It really concerned me because the local kids liked to splash in the streams, the beautiful blue heron bathed and drank from that same dirty water, and many people at the edge of the city still drank from well water. Most importantly, I didn't want whatever was in those streams to end up in our garden or in the city's water supply. I suspected the pollution might have something to do with a factory that operated about four miles upstream, but I didn't really know. A bunch of residents were getting together with the local watershed commission next week to form a committee to investigate the problem further.

It was hard to believe that these beautiful wetlands used to be the site of an old parking lot. The developer had torn up all the asphalt when he built Sunny Marsh, and restored the land to the wetlands that had once spread for miles before it was paved over in the 20$^{th}$ century. I had no idea my city sat on a filled marshland at the mouth of a river, but an interactive set of digital maps on display in the community common room illustrated how the marshes had been filled as the population grew larger and larger. Now, people were realizing the value that these wetlands held, and were bringing them back to the surface. Seeing the wetlands completely soaked this morning, I now understood what people meant when they said that wetlands acted like giant sponges. I could just imagine the flooding that might result if all this water had nowhere to go.

I rolled out of bed and activated the digital display on my wall. The whole wall came alive with a soft blue and green design I had downloaded from the internet. Every wall in our unit was embedded with tiny LED lights, and could therefore be customized with any design I could find and download from online. These "digital wallpapers" synched seamlessly with our energy monitoring and feedback systems to display all kinds of useful information about our energy consumption and resource use. Best of all, I could program the displays to provide this information in any format I desired.

The upper portion of my wall showed a long red bar representing our family's energy budget for the month. The bar was only ¼ full, meaning we were well under our monthly cap. The homeowner's association had voted to cap each household's energy to 450 kW per month – a number that would reduce our energy use to 50% below the national average home's energy consumption. So far we were well on track to reduce it by even more. According to our household's energy budget, we had only spent $17.60 on electricity for the month with two weeks to go. According to my wall display, we were currently buying electricity at .125 cents/kW. As long as prices held steady, which I expected at this time of year, we would spend even less than we did last month. That put us in second place behind the Smith's across the street for the least amount of energy used in the entire community. If we finished first for the month, we would have the satisfaction of paying the lowest energy bill, and the amount of money we saved would be matched by a local non-profit group and donated in our name to the local land conservation trust.

Our energy monitors made it really easy to save energy. Before we moved in, I had no idea how much energy our appliances and electronics used -- even when they were turned off. Now we had indicator lights in every room that showed us how much energy every appliance, light, or electronic device used. The real-time cost of energy downloaded every 30 minutes from the power company, so if it got very expensive we could "power down" our home. The energy monitors also showed that everyone else in the development was well on track to stay within the energy budget this month except for one or two families living down the street.

I went into the bathroom and got in the shower. A blue LED bar, much like the red bar displaying energy use, spread across the shower wall to show our remaining water budget. I had been concerned about how much water we were using, particularly since it hadn't rained in so long. As of yesterday we had almost reached our monthly limit. This morning, however, I realized that the bar, which was nearly full the night before, was now only half full. I was relieved – the cisterns must have been filled overnight to provide us with a new supply of reusable water that didn't count against our water use.

After five minutes in the shower, I slowly felt the water turn from hot to warm—a signal that it was time to get out. I dried off, got dressed, and went downstairs. On the way down, I stuck my head into my son's bedroom. His walls were covered in digital baseball motif resembling Fenway Park. The left field scoreboard filled the far side of his room, but instead of runs, hits, and errors, it showed his energy and water use for the month. Together we had programmed a $10 limit on the electricity he could use on television, computer, and all the other electronic gadgets he had in there. My wife and I agreed that however much money he saved by staying under his budget, we would roll into a running fund to buy a new baseball glove. He had downloaded a game for his wall that synched up with the monitoring system, automatically kept track of his savings, and displayed it as a dollar amount on the baseball scoreboard.

"Good morning," I said.

"Hey," he responded without pulling his head out of his book.

"How much more for the baseball glove?" I asked.

He glanced at the wall. "15 bucks."

I looked over at his television. It was turned off, but its outlet glowed red to indicate that it still was drawing power. "Your TV is sucking," I said.

"It was windy last night – the windmills generated a lot of electricity," he flatly responded.

"Don't waste it – you want that glove?"

Without looking up, he reached up and hit a button on a small digital display above his head. The red light on the outlet turned off.

"I'm going downstairs, you want breakfast?"

"Nah," he replied, still lost in his book.

I walked downstairs to the kitchen. With the water levels so high, the view out the kitchen windows made me feel as if I was swimming in the wetlands. The sunlight glinted off a field of solar panels that were designed to look like large flowers sprouting from the ground. They faced directly into the sun, and just like sunflowers, would follow the sun's path all day as it moved from east to west.

My wife had left a note on kitchen counter. "I'm in the garden," it said. "Will you refill the cleaning supplies?" Next to the note were two clear plastic bottles.

I put two slices of bread in the toaster. Turning the power on illuminated a small screen on the wall that started tabulating the running cost of energy used to make the toast. The kitchen was littered with the remains of last night's dinner. I picked up the trash and cleaned the dishes, carefully separating compost, recyclables, and trash into the separate trash bins. As I filled each one, the weight of each container was recorded in the resource management system that tracked our energy and water use. So far, the community had prevented almost one ton of compostable or recyclable waste from going to the city landfill!

After I ate, I made a list of the errands I had to run for the day, grabbed the two empty plastic bottles, and stepped outside into the direct sunlight. Our unit was clustered with 8 others around a large community garden. I could smell the damp soil and could hear the streams of water still trickling off the roof and into the large metal cisterns that collected water to irrigate the gardens. The cisterns were built by a local artist, and every year at the Spring Festival, the kids would paint each one a bright new design to mark the start of the growing season.

My wife and two other gardeners were bent over on their knees as they chatted and planted seeds for the summer vegetables. Our neighbor James raked up leaves, branches, and other debris littering the garden that had been blown around during the storm, and wheeled them over to the community compost heap. His daughter filled another wheelbarrow with compost to fertilize the new seeds being planted. The compost smelled fresh and I saw the steam heat it produced rise from the wheelbarrow in the cool morning air.

I waved as I passed by and walked toward the community center to refill our cleaning supplies. The maintenance crews purchased “green” non-toxic supplies for us in bulk. I fed the dispenser four quarters and held the bottles under the nozzle, filling one with dish soap and the other with all-purpose liquid cleaner. It felt good knowing that we didn’t use toxic chemicals to clean our dishes and counters that we made food on and ate from. I didn’t even realize normal cleaning products were such a problem until we moved to Sunny Marsh. The first time we cleaned our counters with 409, they temporarily streaked black under the sponge. Alarmed, my wife asked our neighbor why that had happened, and she told her that the countertops and fixtures had a special coating that sensed the presence of certain toxic chemicals found in a lot of cleaning products. The black streaks were a signal not to use that product. I have to admit, it was pretty cool! I soon realized that everyone else used these refillable "green" cleaning supplies that the maintenance crews used to clean the common areas. Best of all, they are much cheaper to purchase in bulk then the smelly stuff you buy at stores, and I don't even get headaches from their fumes.

As I left the community room, I noticed a message on the digital bulletin board that reminded me of the community dinner tonight to discuss the planning of the Annual Spring Festival. I had to remember to log onto the web-site to find out what I should bring to eat. I knew my son would be excited about this dinner – he loved planning to paint the cisterns.

I stepped back outside into the light, and looked at my list. I had a lot to do, but I decided to make a quick stop back at the wetlands. I sat down on a bench and watched the ducks dry their wings by flapping them in the air. My eyelids started to grow heavy…that 3:30am wake-up call was catching up to me. I closed my eyes and dozed off to sleep feeling the warmth of the sun on my face.

### *The Details of Sunny Marsh*

***Wetlands.*** The Sunny Marsh community is built alongside a restored wetland that evokes the memory of the landscape that once dominated the region. Nesting boxes and birdfeeders are scattered throughout the wetlands to attract birds. A raised boardwalk snakes through the wetlands inviting walkers to explore the wildlife inhabiting the area. It also links to a publicly accessible regional trail network. The trail leads past several small picnic and sitting areas which encourage residents to stop, rest, and take in their surroundings. Some of the sitting areas are designed as demonstration micro-climates to show how an understanding of sun, wind, and other materials can be used to create zones that are hotter in winter months and cooler in summer months.

Interpretive signage provided by the local Audubon Society highlights important geological, ecological, and zoological features along the walking trail. The Audubon Society also produced a free podcast that can be downloaded from the Sunny Marsh website that provides a walking audio tour of the area's history and natural systems. The walking path is lined with motion activated, solar-powered lighting to provide nighttime security.

***Gardens.*** Homes are clustered around several large community gardens that provide garden plots for every household. Community gardens offer the opportunity to experience the challenge and reward of growing flowers, herbs, and vegetables. Gardens are irrigated by several above-ground rain harvesting cisterns that are colorfully repainted every year by residents during the community's "Spring Festival" celebration. A meter located near the cisterns' spigots displays the amount of rainwater available for irrigation. Free garden fertilizer is available from the community composting station. During the annual "Harvest Day Festival" hosted by the residents of Sunny Marsh every autumn, city residents are invited to a festival with games, events, music, and farm stands where gardeners can sell off their additional produce. If a household chooses not to plant a garden, it is transferred into a communal plot maintained by a non-profit youth organization called “City Grow” that grows produce for low-income families.

***Connection between Indoors and Outdoors.*** All interior spaces are infused with natural daylight to demonstrate that artificial lighting can be minimized, maintain a sense of airiness and light indoors, and create a strong connection to outdoor conditions. Every unit features private outdoor decks that can be enclosed in winter months to create warm “sun-space”. In addition, each unit provides a relationship to surrounding natural contexts with decks, windows, and views that connect residents to the wetlands.

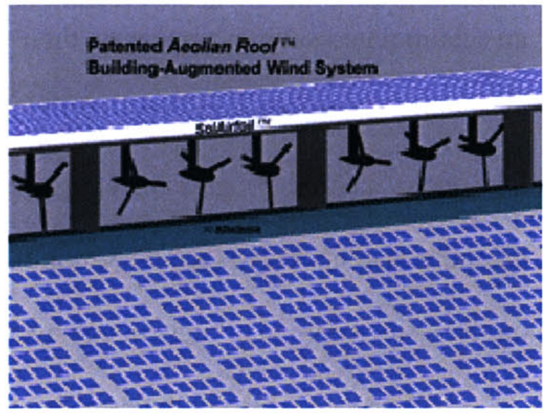
***Connection to Energy Flows.*** All homes are networked with a central computerized system that monitors, tracks, and itemizes energy production and consumption in each household, common area, and the development as a whole. This information is displayed on customizable LED displays embedded in every wall. These displays can be programmed in different sizes and styles to meet the preference of each individual in a family. Digital “wallpaper” can be downloaded from the internet to change the color and design of each display. These displays disaggregate energy use to show residents specifically how their different actions have an impact on energy consumption and associated cost. Aggregated energy data from every household is publicly accessible through the monitoring system so residents can compare their energy use with other families (disaggregated data remains private). Energy consumption is displayed in real-time kilowatt and monetary units; a feature which enables residents to visibly see energy costs add-up over time.

Community and household energy budgeting is an important feature of the energy monitoring system. For example, the homeowners association can decide that each dwelling unit is entitled to $40 dollars per month. Households staying under this cap see an accumulated savings appear on their wall displays over a period of time. Households exceeding this allotment pay a premium for every unit over the cap consumed. Each household can also program an energy budget for the rooms in their own unit. For example, parents may place a $5/month limit on each child's bedroom, a $15/month limit on the living room and kitchen, and a $50/month limit for the entire household.

The system also includes a "smart" net-metering feature. Real-time energy costs, which can fluctuate as often as every thirty minutes based on the grid's energy demand, are downloaded into the system to reflect the actual cost of the energy being consumed. When energy demand is high and rates increase, the system issues a notification to consumers with an alert on the digital display, via email, or by cell phone. Users can then power down certain rooms, appliances, systems, and outlets with the touch of a button.

Every appliance, plug, and light switch contains a small color coded LED light that glows a different colors to indicate different energy use levels, thus helping residents understand the relative power consumption of different activities. Outlets glow red to indicate the presence of "energy vampires" (electronic equipment that consumes power even when turned off). All plugs are outfitted with on/off switches to allow users to conveniently kill power flows to "vampires" without unplugging equipment. A control panel located near the front entry door alerts residents of lights, appliances, or other devices that have unnecessarily been left on when a person is leaving the unit; users can then turn off a television in the kids' room with the touch of a button.

***Highly Visible Renewable Power.*** The development in outfitted with an Aeolian Roof, a unique and highly visible integrated wind and PV roof system that utilizes an air foil to accelerate air flows through micro-wind turbines to generate on-site power (Taylor 2000). Additional photovoltaic panels are incorporated in a "solar meadow" comprised of PV "tracking panels" that automatically follow the path of the sun throughout the day to ensure maximum solar exposure. Real-time renewable power production data are displayed on each household's digital display and on a large dial in the development's "community room". If more energy is produced than consumed, the price or kilowatt-hour meter runs backward to show the impact of on-site, "free" power generation. Weather and climatic conditions are tracked and correlated with PV and windmill performance to show residents how seasonal and weather conditions can impact energy production.




**An Aeolian roof provides renewable power while stimulating inquiry. Image source: http://www.eunrg.com**

Heat is furnished through an on-site, community operated, wood-pellet furnace system. Households share responsibility for feeding the biomass system using a rotating voluntary sign-up system. Residents who volunteer to load the furnace receive extra units in their energy budget each month. Wood-pellets are delivered every other month to a small holding silo located next to the biomass furnace. The wood-pellet manufacturer regularly prunes on-site fruit trees and adjacent woodlands, and brings the coppicing back to the wood-pellet plant to be processed.

***Daylight, Ventilation, and Solar Heating Control.*** Windows, shutters, shades, and lights are all wired to be adjusted at the touch of a button. They may also be programmed to automatically adjust to changing weather and solar conditions so that residents stay comfortable and the building operates at maximum energy efficiency. For example, at night during winter months, residents may automatically close all household shutters at the touch of a button in the evening to trap collected solar heat. Daylight sensors work in conjunction with artificial lighting to automatically achieve the necessary levels of desired lighting without consuming excess energy.

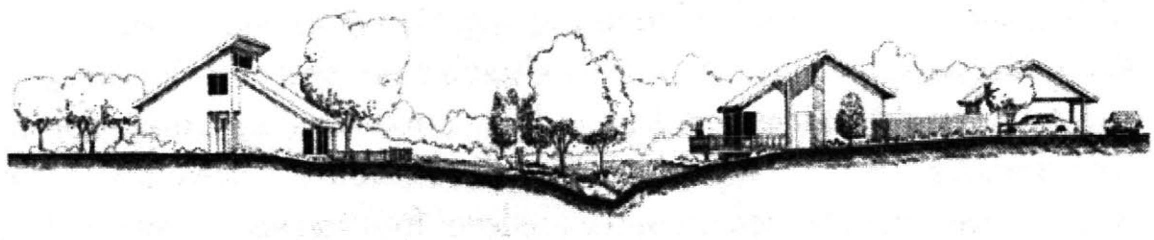
Residents are free to override any programmed automated systems. However, if automated systems are overridden, embedded LED lights in the shutters, curtains, and light bulbs will change color to alert residents that the system is not performing at maximum efficiency. For example, if lights are turned on at full power despite the presence of sufficient daylight, they might glow a hot orange. If shutters remain closed when they should be left open, they might turn a shade of blue. These indicating colors may be adjusted to match a user's personal taste. This sensing system is linked to the energy monitoring system; when the house runs at less than maximum efficiency, the monetary value of wasted energy is tabulated and displayed.

These dynamic systems show residents how shifting solar, weather, and climatic conditions can influence heating, cooling, and lighting requirements. They also illustrate key principles of passive solar heating, day lighting, and ventilation, and demonstrate that solar energy and daylight, if properly controlled, can serve as a "cheap" alternative to fossil fuels.

***Water Metering, Budgeting, Drainage, Treatment, and Discharge.*** A water monitoring system is linked to the energy monitoring wall displays. Like the energy monitoring system, the water monitoring system lets residents disaggregate and itemize sources of household water consumption, monitor the reserves of grey-water and harvested rainwater, and program water consumption budgets. Sensors built into the plumbing systems alert residents to the presence of leaks. All of this information is available in real-time through LED displays located in bathrooms and kitchens.

Water fixtures such as sinks and showers may be programmed to respond to a user's water consumption levels. For example, a resident may program a 5 minute maximum shower length. If someone showers for more than 5 minutes, the shower head might slowly turn from blue to red, or hot water might gradually turn cold to prompt the person to end their shower.

In addition to providing information about water use, the building and site are designed to show residents how water moves through their homes and landscape. After potable water is used in sinks, showers, and appliances, it is re-circulated through a grey-water system for use in the dual-flush toilet systems. Dual-flush toilets allow users to control the amount of water used to flush liquid and solid wastes. Toilet wastewater is pumped directly to an on-site greenhouse containing a Living Machine for treatment. The Living Machine, which is operated through an agreement with the municipal water company, is open to the public and features an exhibit that shows users how the wastewater purification process works. The solid organic byproduct from this process is packaged and distributed locally as revenue generating organic fertilizer. The clean water discharged from the Living Machine moves through a series of vegetated, open-channel drainage swales that purifies surface run-off.



**Open channel drainage systems create streams and creeks which demonstrate the principles of storm water run-off while providing aesthetic and recreational value.**
**Image source: Francis 2003**

Rainwater is captured in large surface cisterns used to irrigate community gardens and act as a reserve water supply in case of drought. Each cistern has a meter located next to the spigot that indicates the amount of water remaining in the tank.

In addition to monitoring water quantity, the integrated water system also monitors water quality. Special sensors placed in rain-water capture cisterns, storm-water channels, and in potable water plumbing identify the presence of pollutants in water, reveal how storm water channels effectively filter run-off pollutants, and demonstrate the difference of water quality between potable water and contaminated urban run-off. This information helps remind people that water quality is an issue with local and regional impacts.

***Chemically Responsive Materials***. Materials such as kitchen countertops, walls, floors, and bathroom fixtures used throughout the development contain special coatings that sense the presence of environmental toxins. For example, if a cleaning or other solution with toxic chemicals, phosphates, or other potentially dangerous compounds is wiped on the kitchen counter, the tub surface, or is poured down a drain, the normally white surface will temporarily streak black to alert residents that use of the solution should be discontinued.

***Air Quality Sensors.*** Sensors located throughout each household will trigger an alert if poor indoor air quality is detected. This prompts users to automatically open windows and bring fresh, clean air into the household. In addition, the outdoor air quality index data that currently appears in newspaper weather forecasts is automatically downloaded and displayed on each household's wall display system.

***Convenient and Monitored Waste Disposal.*** All kitchens contain separate bins for trash, recycling, and composting separation. Each bin measures the weight of material being disposed. Residents are charged a disposal rate per pound of garbage generated. This disposal price is offset by a credit for material sent to the communal compost center and recycling station. The weight of waste material is recorded for individual households and the development as a whole. It is then sent to the kitchen's LED wall display. By showing the amount of material that is diverted away from landfills, residents see how individual actions can add up to big results.

In addition to the waste disposal system, a digital community exchange bulletin board enables residents to post items they wish to trade or give away. This creates an alternative to sending reusable items to the landfill. The digital bulletin board is accessible through the development's web site and each household's LED displays.

***Green Maintenance Plan.*** Property management and maintenance crews follow a strict green maintenance protocol for common areas. Residents are expected to follow similar protocols for taking care of private space. Only non-toxic, "green" cleaning materials are permitted within the development. Chemical pesticides and herbicides are also not permitted. The maintenance office stocks a wide range of "green cleaning" products that they order in bulk. Residents are given three plastic bottles to refill with various cleaning supplies at cheap wholesale prices from automated bulk dispensers in the community room. This eliminates the hassle associated with finding "green" cleaning products at the supermarket, and demonstrates the commitment of the community to sticking to the green maintenance protocol. In addition, the maintenance crew's maintenance vehicles are painted bright green and have signage indicating they run on rapeseed bio-fuel.

***Physical Space to Foster Community.*** A dedicated community room serves as a gathering and meeting space for the homeowners association and various citizen committees. One such group, the "Energy and Environment Committee" is composed of several residents who oversee energy and water budgeting allotments, monitor development wide energy usage, and train new residents to optimize the features of their homes. The committee also organizes community environmental activities such as the Spring Festival, Harvest Day Festival, Neighborhood Clean-up Day, and tours of the

Living Machine. The community room holds the satellite offices of "City Grow", the non-profit group overseeing the community garden.

In addition to serving as committee and office space, the community room can be reserved for large dinner gatherings, speakers and seminars, parties, or any other function the residents choose. The space contains insulated lock boxes for organic produce, meat, and dairy delivery from a local organic farm. Ordering is done online and delivered in twice weekly bulk shipments to reduce transportation costs and provide residents with cheap bulk pricing.

The community room highlights the sustainable and low impact features of the development. One wall is cut away and encased in glass to reveal extra blown cellulose insulation in the frame and the plumbing and electrical systems within the wall. Every appliance, material, and product in the community room and its small kitchenette has a small label that states its embodied energy figure. An interactive display features photographs and models that document the design and construction process, and show how certain features of the development, such as solar hot water heaters, PV panels, and passive solar heating systems, operate. An entire wall of the common room is filled with an interactive display entitled, "Where Do Your Resources Come From?" This interactive map highlights the locations of power plants, reservoirs, and landfills that support daily life in the community, and tracks the flow of resources from source to sink so resident can see how they personally fit in the resource flow.

Sunny Marsh also includes a community fitness center. Exercise bicycles, stair machines, and other equipment are set up to capture excess energy generated by workouts and feed the local energy grid as another source of on-site renewable energy. A large display in the fitness room shows the cumulative real-time kilowatts produced through exercise.

***Transportation.*** The development operates a free shuttle bus during the morning and evening commutes between the housing community and a commuter rail train station two miles away. The shuttle stops in several locations along the way to pick up residents from surrounding neighborhoods for a small charge.

Every parking spot contains an outlet for residents to charge electric vehicles with power drawn from on-site PV panels and windmills. Whenever a resident plugs into the power jack, personal driving data regarding energy consumption is uploaded to their household's energy monitoring system and incorporated into their energy budget. When the car is plugged in, residents may also upload their music, driving directions, schedules, phone and address books, and other personal data into their car's computer system as if they were synching an iPod to a computer. The development also provides three shared electric vehicles available for resident use.

### *Conclusion*

The key to better natural resource protection and conservation does not rest wholly in efficient buildings, economics, or information. A truly holistic solution must also respond to the deeply rooted behavioral qualities that inhibit people from connecting with natural resources and systems. Current residential design and development patterns numb the senses, mask consequences, and perpetuate disconnections that doom larger efforts to promote more effective environmental stewardship at the individual level. If people do not value the function of natural systems, they will see no reason to protect them. If people fail to recognize when they are wasting energy, they will have no means to stop it. If people feel no duty to neighbors and future generations to conserve limited resources, they will possess no impetus to take action.

In contrast, the pedagogical design guidelines proposed in this paper aim to "re-physicalize" the built residential environment by connecting people to the natural resources and systems that support them. In doing so, American housing developments can help develop and support a population that 1) appreciates and understands natural resources and processes, 2) is capable of altering behavior to reduce greenhouse gas emissions, conserve energy, decrease household waste, and curb excessive water consumption, and 3) actively recognizes and addresses newly emerging environmental threats.

No single design or programming strategy is sufficient for overturning years of ingrained habits. However, a web of interconnected strategies that achieve the proposed guidelines can help build the contexts for new understandings and behaviors to take shape. The pedagogical design framework's overlapping and integrated nature presents many opportunities to create design strategies that fulfill the goals of multiple guidelines. In addition, as the illustrative scenario above suggests, many opportunities exist to weave these guidelines together with appropriate technological, economic, and educational strategies. A multi-pronged and integrated approach is necessary to reach the largest audience and support the growth of a more sustainable society.

The proposed guidelines are not complicated, and their envisioned applications are not inconceivable in today's world. It is possible to achieve the intents of each guideline using strategies, technologies, and knowledge that already exist. However, unraveling the issues that necessitate the creation of these guidelines is complex. The real value of this framework, therefore, is not in the specific design strategies or techniques it informs, but in the organization and method of approach it offers for grappling with these issues in each specific site context.

As a result, this pedagogical design framework does not represent an arrival at a solution. Rather, it is a point of departure for further exploration. Other important guidelines must be proposed and examined; new strategies must be discovered. Designers and developers who are interested creating such communities should envision future projects as innovative R&D opportunities. Small-scale model demonstration projects showcasing the beauty, convenience, and increased quality of life that these homes afford must be built to test market viability and user preferences, and to serve as a platform for studying the real and perceived behavioral impacts of the utilized design strategies. Ecologists, psychologists, and educators should be consulted throughout design, construction, and occupancy. Partnerships with major systems, materials, and fixtures manufacturers should be pursued to conceptualize and test new product designs. New findings will lead to subsequent amendments and iterations of these guidelines, a more refined menu of strategies used to achieve them, and better residential housing products that effectively help people to reduce their own environmental impacts while best meeting the demands of the market.

While there is still much to be learned, the promise that pedagogical design holds as a compliment to technology, economics, and education is too great to be ignored. Addressing environmental threats without empowering individuals with the knowledge, desire, and ability to take responsibility for their own negative environmental impacts is the equivalent of fighting a war with an apathetic army. The design and development community must push forward with further exploration of pedagogical design approaches in housing contexts. The well-being of the planet does not depend on it – but the well-being of humanity does.

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